Portland Harbor RI/FS
Round 1 Work Plan

APPENDIX B:
ECOLOGICAL RISK ASSESSMENT APPROACH
ATTACHMENTS B1 THROUGH B9

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Attachment B1: Benthic Macroinvertebrate Community Sampling

1.0 INTRODUCTION

Benthic invertebrates serve various functions in large river ecosystems. They often comprise a significant portion of the heterotrophic biomass in a river system (Jahn and Anderson 1986), and therefore serve as a principal food resource for higher-trophic-level consumers. Invertebrates also control energy flow by acting as the principal processor of organic matter (Merritt et al. 1984).

Benthic invertebrates utilize various habitat types within a large river ecosystem. These habitats can generally be divided into soft and hard substrates, with soft substrates supporting an infaunal community and hard substrates an epifaunal community. These habitats are typically quite different in their community structure and function.

To date, limited studies have been conducted to quantify the infaunal and epibenthic community in the Lower Willamette River. Hjort et al. (1984) studied the epibenthic community associated with reveted banks well upstream from the ISA; Ward et al. (1988) collected benthic samples from hard and soft substrate from 5 stations in the ISA; Tetra Tech (1994) sampled the infaunal community from six stations in the LWR as part of an assessment of the entire Willamette River; Dames and Moore (1998) sampled the infaunal community from several stations near Swan Island; and Landau (2000) collected epibenthic and infaunal invertebrates from hard and soft substrates around Ross Island. The above studies suggest that oligochaete worms and chironomid larvae (midges) dominate the benthic macroinvertebrate community in the LWR.

Benthic communities vary spatially; so more sampling was needed to characterize the infaunal and epibenthic communities within the ISA (RM 3.5 to 9.2). Therefore, in support of the Portland Harbor ecological risk evaluation, the lower Willamette Group (LWG) conducted separate surveys of the infaunal and epibenthic macroinvertebrate communities of the lower Willamette River (LWR).

In October of 2002, Striplin Environmental Associates collected grab samples of the infaunal community from 22 stations between RM 2.4 and 9.8 of the LWR. Direct quantitative sampling of the epibenthic macroinvertebrate community, however, is more difficult. Artificial substrates that can be colonized by epibenthic macroinvertebrates are one accepted methodology for collecting a surrogate sample of an epibenthic community (ASTM 1997). Therefore, in order to sample the epibenthic macroinvertebrate community, Windward Environmental deployed artificial substrates between river mile 3.5 and 9.2 of the LWR in the summer of 2002. As specified in the Round 1A Sampling and Analysis Plan (SAP) (Striplin et al. 2002b) and the Round 1 Field Sampling Plan (Striplin et al. 2002a), these surveys will be used to develop an understanding of the potential exposure pathways to fish and other wildlife associated with benthic communities in the ISA.

2.0 OBJECTIVES

The objective of these studies was to develop a better understanding of the structure of the epibenthic and infaunal macroinvertebrate communities for use in the preliminary risk evaluation. Understanding which organisms are present and their relative abundances will allow for a more accurate description of potential exposure pathways to fish and other wildlife associated with benthic habitats in the LWR and greater refinement of the conceptual site model.

3.0 METHODS

This section describes the field methods used obtain samples of the infaunal and epibenthic invertebrate communities and the laboratory methods used to enumerate and identify the macroinvertebrate species present.

3.1 Field methods

3.1.1 Epibenthic community collection

3.1.1.1 Artificial substrate deployment

Hester-Dendy multiplate samplers were used as an artificial substrate to characterize the composition of the epibenthic community at ten stations within the lower Willamette River ISA and at two upstream reference stations (Figure 1). Four of the stations within the ISA were located in protected backwater areas and six were at locations adjacent to the river channel. One reference station was located adjacent to the river channel and one was located in a more protected, shallow embayment.

EPA-style, round Hester-Dendy multiplate samplers were used. This style sampler consists of fourteen 3-in.-diameter plates made of tempered hardboard. The plates are separated by spacers to allow for a range of species to colonize the open substrate. Each sampler provides a surface area of 0.116 m^2 for colonization.

Three separate arrays of multiplate samplers, with seven samplers per array, were deployed at each of 12 stations, for a total of 252 multiplate samplers (Figure 2). At each station, one array was for the assessment of epifaunal community structure, the second array was for tissue analysis, and the third array was a backup array in case of sampler loss. The sampler arrays were randomly selected for the various analyses just prior to recovery. Because at least five replicate multiplate samplers are necessary to ensure statistical precision and accuracy (ASTM 1997), each array consisted of seven multiplate samplers to allow for potential sampler loss while still retaining an adequate number for statistical precision. Where more than five replicate multiplate samplers remained at the time of recovery, five were randomly chosen for processing.

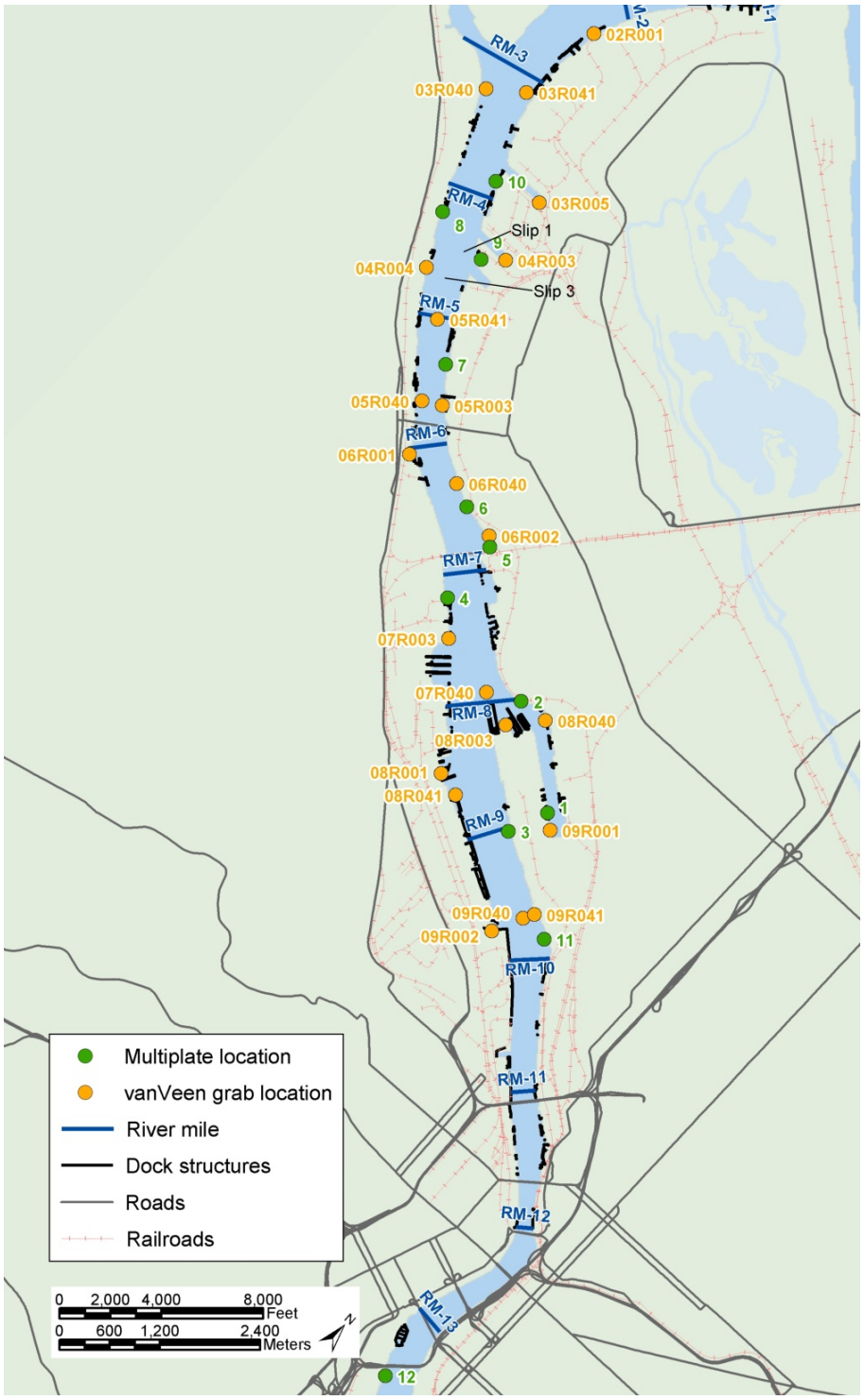

Figure 1. Locations of benthic community samples

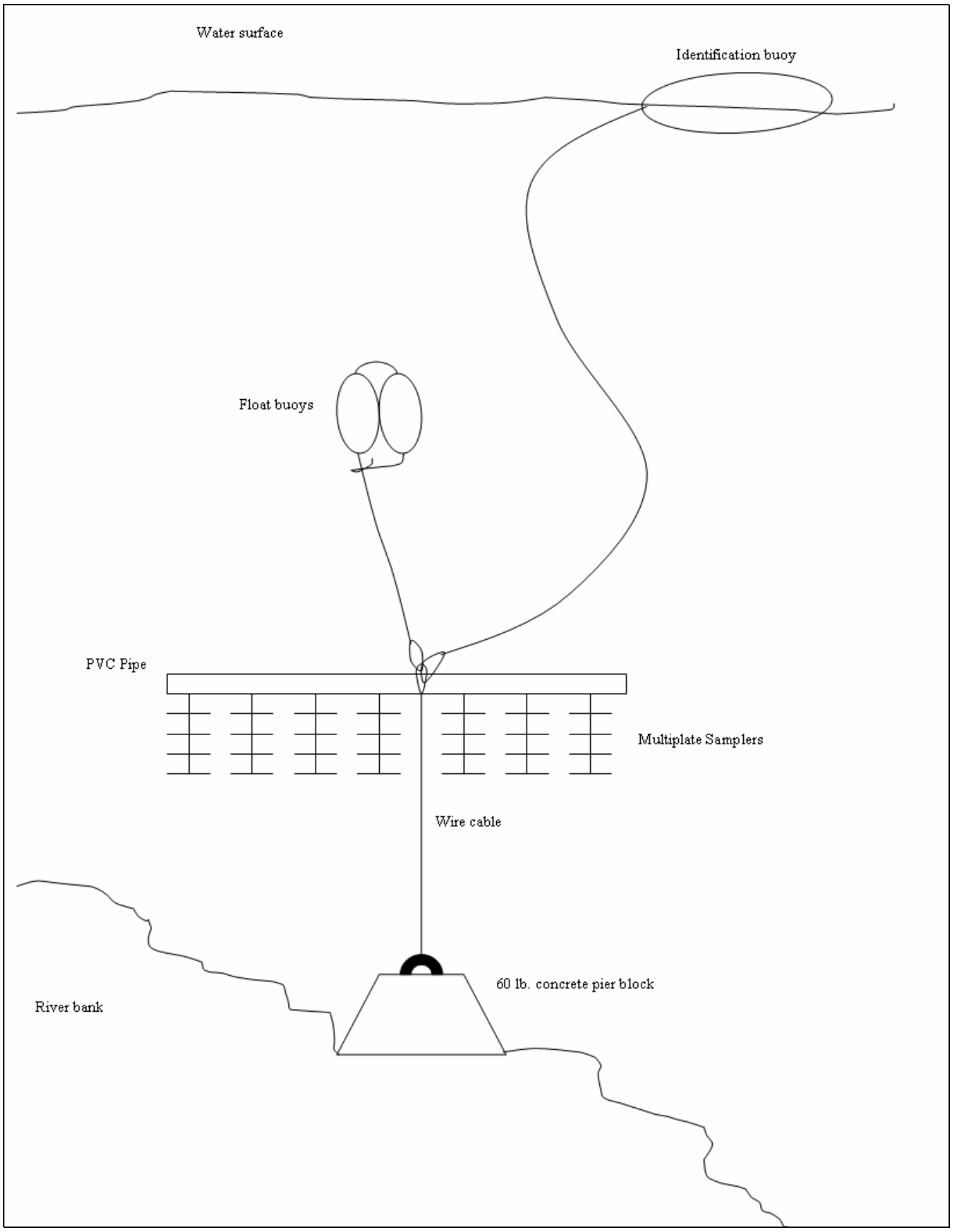

Figure 2. Design scheme for an array of 7 multiplate samplers

Multiplate sampler arrays were anchored with a double-buoy system (Figure 2) to maintain the samplers at a constant distance of ~1 meter above the river-bottom to prevent excessive siltation if the river depth fluctuated during the deployment. Each identification buoy and float buoy was labeled with the sample station number (1-12) and the array replicate identification (A, B, or C) for easy identification during retrieval. Each individual multiplate sampler on an array was also labeled with the station number, array identification, and multiplate sampler replicate number (1-7). The samplers were deployed on July 15th and 16th, 2002 and were retrieved six weeks later on August 27th and 28th, 2002. A hand-held global positioning system (GPS) unit was used to determine the geographic coordinates of each sample station at the time of deployment. Station coordinates are presented in Table 1.

Table 1. Multiplate sampler location and deployment information

Station #	LWG #	Location		Date Deployed	Date Retrieved
		Lat. (N)	Long. (W)		
LWG01	08R034	45° 33.77’	122° 42.63’	7/15/02	8/28/02
LWG02	08R033	45° 34.19’	122° 43.51’	7/15/02	8/28/02
LWG03	09R027	45° 33.51’	122° 42.78’	7/16/02	8/28/02
LWG04	07R024	45° 34.36’	122° 44.66’	7/15/02	8/27/02
LWG05	06R028	45° 34.79’	122° 44.69’	7/15/02	8/27/02
LWG06	06R027	45° 34.88’	122° 45.10’	7/15/02	8/27/02
LWG07	05R020	45° 35.47’	122° 46.14’	7/15/02	8/27/02
LWG08	04R025	45° 36.19’	122° 47.12’	7/16/02	8/28/02
LWG09	04R026	45° 36.13’	122° 46.56’	7/16/02	8/28/02
LWG10	03R030	45° 36.57’	122° 46.95’	7/16/02	8/28/02
LWG11	09R028	45° 33.15’	122° 41.86’	7/16/02	8/27/02
LWG12	13R001	45° 30.36’	122° 40.20’	7/16/02	8/27/02

3.1.1.2 Artificial substrate retrieval

Before retrieval, array replicates were randomly assigned for taxonomic identification, tissue analysis, or archiving, and 5 multiplate replicates on the array chosen for taxonomic identification were randomly chosen for preservation. During sampler retrieval, the array selected for taxonomic identification was collected first. Samplers were suspended just above water level and the five replicates selected for preservation were immediately clipped into individual Ziploc bags. The multiplate samplers were immediately preserved in approximately 500 mL of 95% denatured alcohol and triple bagged to prevent loss of preservative. Each sampler was then labeled with station location and identification number, retrieval date, and multiplate sample identification. The multiplate samplers were placed in coolers and shipped overnight to Ecoanalysts, Inc. in Moscow, Idaho for sorting and taxonomic identification.

Of the thirty-six arrays deployed in the lower Willamette, only one array (station LWG06) was vandalized. It was found pulled up on shore and, therefore, was not used. Every other array was found in its original deployment location with at least 6 multiplate samplers still attached. Five of the 35 remaining arrays were missing one multiplate sampler, but all other arrays retained all seven multiplate samplers. Detailed notes from the deployment and retrieval are included in the field report in subattachment B1A, and a list of the array and multiplate replicates assigned for taxonomic analysis is presented in Table 2.

Table 2. Multiplate arrays and replicates randomly selected for taxonomic analysis

Station #	LWG #	Taxonomic Array	Multiplate Sampler Replicates Used
LWG01	08R034	B	2, 3, 4, 6, 7
LWG02	08R033	A	1, 2, 3, 5, 7
LWG03	09R027	B	1, 3, 4, 5, 7
LWG04	07R024	C	1, 2, 3, 4, 6
LWG05	06R028	A	1, 3, 5, 6, 7
LWG06	06R027	B	1, 2, 3, 4, 5
LWG07	05R020	B	1, 3, 4, 5, 6
LWG08	04R025	A	3, 4, 5, 6, 7
LWG09	04R026	C	1, 2, 4, 5, 7
LWG10	03R030	A	1, 4, 5, 6, 7
LWG11	09R028	C	1, 4, 5, 6, 7
LWG12	13R001	A	1, 2, 3, 6, 7

3.1.2 Infaunal community collection

Infaunal benthic community sampling was conducted from October 22 to October 25, 2002. Samples were collected from 22 stations within the lower Willamette ISA using a 0.1 m^2 van Veen grab sampler. The van Veen sampler captures sediment and associated fauna from a 0.1 m^2 area and 15 cm depth. Twelve of the 22 stations were co-located with pre-assigned sediment and fish sampling stations in shallow, nearshore locations used for the round 1 preliminary risk evaluation. The other 10 stations were nearshore and in-channel stations used to collect additional sediment chemistry data (Figure 1).

The shipboard global positioning system (GPS) was used to locate each sample station (Table 3 presents the station coordinates, see the Round 1 Field Sampling Report (2003) for more details on navigation). Upon arrival at each station, benthic community samples were taken with the first casts of the van Veen sampler. The water depths for each benthic community grab are presented in Table 3. If the benthic ecologist onboard determined the grab was acceptable for processing, its entire contents were emptied onto a 0.5 mm sieve. Site water was used to gently wash the

sediments through the sieve and the material retained was rinsed into labeled polyethylene bags. Excess water was removed and the sample was immediately preserved in 88.3% denatured ethanol. Samples were placed in coolers and stored in the LWG field lab until transported to the SEA offices in Olympia, WA.

Table 3. Infaunal benthic community composite sample information

LWG Sample #	Station #	Date Sampled	Station Type	Water Depth (m)	Location of Station	
					Lat. (N)	Long. (W)
LWG0102R001BNS015	02R001	10/24/02	Co-located	6.2	45° 37.7075	122° 47.2134
LWG0103R005BNS015	03R005	10/24/02	Co-located	3.5	45° 36.6561	122° 46.5207
LWG0103R040BNS015	03R040	10/25/02	Channel	4.5	45° 36.9698	122° 47.5990
LWG0103R041BNS015	03R041	10/25/02	Channel	14.1	45° 37.1277	122° 47.3016
LWG0104R003BNS015	04R003	10/23/02	Co-located	8.5	45° 36.2345	122° 46.3883
LWG0104R004BNS015	04R004	10/23/02	Co-located	2.9	45° 35.8512	122° 46.8809
LWG0105R003BNS015	05R003	10/23/02	Co-located	3.0	45° 35.2607	122° 45.9065
LWG0105R040BNS015[a]	05R040[a]	10/25/02[a]	Channel[a]	17.3[a]	45° 35.1930	122° 46.0721
LWG0105R041BNS015	05R041	10/25/02	Channel	24.1	45° 35.6520	122° 46.4793
LWG0106R001BNS015	06R001	10/23/02	Co-located	0.8	45° 34.8805	122° 45.8211
LWG0106R002BNS015	06R002	10/23/02	Co-located	na	45° 34.8417	122° 44.7672
LWG0106R040BNS015	06R040	10/25/02	Channel	5.7	45° 34.9480	122° 45.3164
LWG0107R003BNS015	07R003	10/22/02	Co-located	na	45° 34.1721	122° 44.3976
LWG0107R040BNS015	07R040	10/25/02	Channel	19.1	45° 34.0798	122° 43.8033
LWG0108R001BNS015	08R001	10/22/02	Co-located	0.9	45° 33.4930	122° 43.5999
LWG0108R003BNS015	08R003	10/22/02	Co-located	na	45° 34.0079	122° 43.4654
LWG0108R040BNS015	08R040	10/25/02	Channel	8.9	45° 34.2039	122° 43.2237
LWG0108R041BNS015	08R041	10/25/02	Channel	7.9	45° 33.4520	122° 43.3679
LWG0109R001BNS015	09R001	10/24/02	Co-located	4.4	45° 33.6986	122° 42.5022
LWG0109R002BNS015	09R002	10/22/02	Co-located	na	45° 32.9596	122° 42.2679
LWG0109R040BNS015	09R040	10/25/02	Channel	23.3	45° 33.1567	122° 42.1336
LWG0109R041BNS015	09R041	10/25/02	Channel	2.5	45° 33.2250	122° 42.0804

[a]: Sample was never processed in the lab

na: not available

Once the community samples were preserved, additional grabs were taken at each station as needed to obtain sediment for chemical analyses. See the Round 1 Field Sampling Report (2003) for additional details on the sediment chemistry samples.

3.2 Laboratory methods

3.2.1 Epibenthic community samples

Immediately prior to sorting, each multiplate sampler was disassembled in a bucket partially full of water. Attached invertebrates were lightly scrubbed off of the multiplate sampler components into the bucket of water and the cleaned components were set aside. The entire contents of the bucket were then emptied onto a 500-µm mesh sieve and rinsed while ensuring that invertebrates remained on the sieve. The contents of the sieve were then rinsed into a gridded, Caton type sample splitter with 70% ethanol. The sample sorter consisted of 8 equally sized grid cells and the contents of the sample were evenly distributed across all 8 cells prior to sorting.

A target count of 500 organisms per sample was specified prior to sorting. Such fixed-count methods have been shown to provide unbiased representations of larger samples (Barbour and Gerritsen 1996). Any subsample needed to consist of at least five hundred organisms to be considered representative of the community from each sampler. The necessary number of grid cells were sorted to achieve the target count of 500 and invertebrates from those cells were placed into one of three vials containing Oligochaeta, Chironomidae, and 'other.' When sorting was complete, the individual vials were labeled and the sorting time, number of organisms, and percent of total sample sorted were noted. The sorted samples were stored until taxonomic enumeration. An additional sorting quality assurance step was completed for each sampler to ensure that each species met a standard removal rate of 90%. The sorting step was repeated for any sampler that failed the QA check.

Chironomidae and 'other' vials were identified at Ecoanalysts' laboratory. The contents of an individual vial were emptied into a Petri dish and invertebrates were sorted to the lowest practical taxonomic level under a dissecting scope. The number of each taxon was recorded and at least one specimen from each taxon was preserved in labeled 1-dram vials containing 70% ethanol for quality assurance and future reference. A second taxonomist verified the accuracy of the identification of all preserved specimens. Finally, 10% of all samples were randomly selected for complete re-identification by a second taxonomist for quality assurance. If necessary, any differences in identification were resolved by sending the specimen to an external expert. Quality assurance checks for both general identification and chironomid identification are reported in Table 4.

Table 4. Multiplate sampler taxonomy QA results

Site	% Similarity
General Identification:	
LWG 03B-MP07	99.58
LWG 05A-MP06	100.00
LWG 09C-MP05	99.17
Chironomid Identification:	
LWG 03B-MP04	96.47
LWG 05A-MP06	94.98 [a]
LWG 09C-MP05	96.55 [b]

[a] QA differences were the result of an *Ablabesmyia* sp. misidentified as a *Larsia* sp. and misidentification of early instar *Dicrotendipes* sp. and *Glyptondipes* sp. larvae in the QA data.

[b] QA differences were the result of a *Phaenopsectra* sp. misidentified as *Sergentia* sp. in the QA data

Oligochaete samples were mounted on viewing slides and labeled. All oligochaete slides were shipped to the oligochaete taxonomic specialist for identification and enumeration.

Bryozoans were noted on many of the multiplates during retrieval, but they were not initially quantified during the above processing. However, residues from the sieving and sorting steps above were retained for all samples, and technicians examined the residues under a microscope to note the presence or absence of bryozoans from each multiplate sampler. However, quantification of bryozoan abundance was not possible at this point.

3.2.2 Infaunal community samples

The preserved van Veen grab samples were shipped to Marine Taxonomic Services (Corvallis, OR) for sorting. In the laboratory, the contents of each sample bag were rinsed into a gridded, Caton sample splitter. The contents of the sample were evenly distributed across eight equally sized grid cells, which allows for subsampling. The entire contents of each of these samples, however, were sorted and identified. Invertebrates from each sample were sorted into one of three vials containing oligochaetes, chironomids (dipterans), and "general." Once complete, the individual vials were labeled, preserved, and stored until shipment of all samples to Ecoanalysts, Inc. for taxonomic identification and enumeration.

Chironomidae and "general" vials were identified at the Ecoanalysts' laboratory in Moscow, ID. The contents of an individual vial were emptied into a Petri dish under a dissecting scope and invertebrates were identified to the lowest practical taxonomic level. The number of each taxon was recorded and at least one specimen from each taxon was preserved in labeled 1-dram vials with 70% ethanol for quality assurance and future reference. A second taxonomist verified the identification of each

specimen archived. Finally, one of the samples was completely re-identified (09R040) by a different taxonomist for quality assurance. The quality assurance step yielded 100% similarity for both the chironomid and "general" identifications.

Oligochaete samples were mounted on viewing slides and labeled at the Ecoanalysts' Moscow, ID laboratory. The slides were shipped to the oligochaete taxonomic specialist for identification and enumeration.

The benthic community from the sample at station 05R040 was never quantified. Examination in the laboratory revealed that the sample was coated in tar, and sorting was not possible.

4.0 RESULTS

A total of 78 taxa from 7 phyla, 12 classes, 18 orders, and 31 families of benthic invertebrates were identified from both the epibenthic and infaunal communities in the LWR. The complete list of taxa collected by both methods is included in Table 5 (tables with landscape orientation are found following the main text of this report).

4.1 Epibenthic community

Sixty-three taxa representing at least 7 phyla, 11 classes, 15 orders, and 23 families were found colonizing artificial substrates placed in the ISA (Table 5). Chironomids, or midges, were the most diverse taxonomic group represented with 27 taxa. Oligochaete worms were the next most diverse taxonomic group encountered with at least 12 taxa identified. Other taxa found were crustaceans (isopods, ostracods, and amphipods), caddisflies, mites, and flatworms. Bryozoans were found on multiplates at all 12 stations. In fact, bryozoans were very common and were found on 54 of the 60 multiplates examined. Because they were never quantified, bryozoan abundance is not included in any of data summarized below. The complete list of organisms identified from each sampler replicate is available from Windward Environmental LLC.

Chironomids and oligochaetes were the most abundant taxonomic groups collected. Crustaceans (almost exclusively amphipods from the genus *Corophium*) were also locally abundant, and outnumbered oligochaetes and chironomids at several stations. Together, these three groups consistently accounted for more than 95% of the organisms present on each sampler.

Taxonomic richness (the total number of taxa present) for each station is reported in Table 6. Stations 8 and 10 had the greatest numbers taxa. A total of 36 species were counted at these open channel sites and almost half of them (17 and 16, respectively) were chironomids. The least diverse community was found at Station 2. Twenty-one species were found at this backwater station and, like Stations 8 and 10, almost half

of them were chironomids. In fact, chironomids consistently accounted for approximately half of the overall taxonomic richness at all multiplate stations.

The greatest total abundance of organisms was found at multiplate Station 1 (Table 7). This is a backwater site located in Swan Island Lagoon and its community was dominated by oligochaetes and chironomids. The other taxa at this station only accounted for about 1% of the organisms found. The station with the lowest abundance was Station 2, located at the mouth of Swan Island Lagoon. Chironomids dominated the benthic community at this station and accounted for more than two-thirds of the organisms collected.

Overall abundance and taxa richness at the two reference stations fell within the ranges observed at the ten stations in the ISA (Tables 6 and 7). Taxa richness was identical at both reference stations, but they differed in the type and abundance of organisms collected. Station 12 was an open channel site and was dominated by crustaceans. Station 11 was in a more backwater location and had lower overall abundance than Station 12. Station 11 was highly dominated by oligochaetes.

Table 5. Taxa identified on multiplate samplers and van Veen grab samples in the Lower Willamette River, 2002

Phylum	Class	Order	Family	Genus Species	Common Name	Type of sample
Bryozoa					'moss animals'	multiplate
Platyhelminthes	Turbellaria				flatworm	multiplate, van Veen
Nematoda					roundworm	multiplate, van Veen
Nemertea				*Protostoma* sp.	ribbon worm	multiplate, van Veen
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Aulodrilus limnobius*	tubificid worm	van Veen
				A. pigueti	tubificid worm	multiplate, van Veen
				A. pluriseta	tubificid worm	van Veen
				Branchiura sowerbyi	tubificid worm	van Veen
				Limnodrilus hoffmeisteri	tubificid worm	multiplate, van Veen
				Quistradrilus multisetosus	tubificid worm	van Veen
			Enchytraeidae sp.		enchytraeid worm	multiplate, van Veen
			Naididae	*Chaetogaster sp.*	naidid worm	multiplate, van Veen
				Dero sp.	naidid worm	multiplate, van Veen
				Nais barbata	naidid worm	multiplate
				Nais pardalis	naidid worm	multiplate
				Nais variabilis	naidid worm	multiplate
				Pristina leidyi	naidid worm	multiplate
				Pristina/Pristinella sp.	naidid worm	multiplate
				Slavina appendiculata	naidid worm	multiplate
				Stylaria lacustris	naidid worm	multiplate
		Lumbriculidae			lumbricud worm	van Veen
	Hirudinea	Euhirudinea	Erpobdellidae sp.		leech	van Veen
	Polychaeta	Canalipalpata	Sabellida	*Manayunkia speciosa*	sabellid worm	multiplate, van Veen
Mollusca	Gastropoda	Basommatophora	Physidae	*Physa sp.*	snail	multiplate

Phylum	Class	Order	Family	Genus Species	Common Name	Type of sample
			Ancylidae	*Ferrissia sp.*	limpet	multiplate
			Planorbidae	*Menetus opercularis*	button sprite	multiplate
	Bivalvia	Veneroida	Corbiculidae	*Corbicula sp.*	asiatic clam	multiplate, van Veen
			Sphaeriidea	*Pisidium* sp.	fingernail clam	van Veen
Arthropoda	Crustacea	Isopoda	Asellidae	*Caecidotea sp.*	isopod	multiplate, van Veen
		Ostracoda sp.			ostracod	multiplate, van Veen
		Amphipoda sp.			amphipod	multiplate
			Hyallelidae	*Hyallela sp.*	amphipod	multiplate
			Corophiidae	*Corophium sp.*	amphipod	multiplate, van Veen
			Gammaridae sp.		amphipod	van Veen
				Anisogammarus sp.	amphipod	multiplate
	Insecta	Odonata	Gomphidae	*Stylurus* sp.	dragonfly	van Veen
		Diptera	Chironomidae	*Alabesmyia sp.*	midge	multiplate
				Billia sp.	midge	multiplate
				Bryophaenocladius sp.	midge	van Veen
				Chironomini sp.	midge	multiplate
				Chironomus sp.	midge	multiplate, van Veen
				Cladopelma sp.	midge	van Veen
				Cladotanytarsus sp.	midge	multiplate
				Corynoneura sp.	midge	multiplate
				Cricotopus bicinctus gr.	midge	multiplate
				Cricotopus sp.	midge	multiplate
				Cryptochironomus sp.	midge	multiplate, van Veen
				Demeijerea sp.	midge	multiplate
				Dicrotendipes sp.	midge	multiplate, van Veen

Phylum	Class	Order	Family	Genus Species	Common Name	Type of sample
				Endochironomus sp.	midge	multiplate
				Eukiefferiella brevicalcar gr.	midge	multiplate
				Glyptotendipes sp.	midge	multiplate
				Harnischia sp.	midge	van Veen
				Nanocladius sp.	midge	multiplate
				Parachironomus sp.	midge	multiplate
				Paracladopelma sp.	midge	van Veen
				Parakiefferiella sp.	midge	multiplate
				Paralauterborniella sp.	midge	multiplate
				Paratanytarsus sp.	midge	multiplate
				Phaenopsectra sp.	midge	multiplate, van Veen
				Polypedilum sp.	midge	van Veen
				Procladius sp.	midge	multiplate, van Veen
				Pseudochironomus sp.	midge	multiplate
				Rheotanytarsus sp.	midge	multiplate
				Stenochironomus sp.	midge	multiplate
				Tanytarsus sp.	midge	multiplate
				Thienemanniella sp.	midge	multiplate
				Thienemanninyia gr. sp.	midge	multiplate
				Xenochironomus xenolabis	midge	multiplate
		Trichoptera sp.	Hydroptilidae sp.	*Hydroptila* sp.	caddisfly	multiplate
			Leptoceridae	*Oecetis* sp.	caddisfly	van Veen
			Polycentopodidae sp.	*Polycentropus* sp.	caddisfly	multiplate
	Arachnida	Acari sp.			mite	multiplate
		Hydrachnida	Arrenuridae	*Arrenus* sp.	water mite	van Veen

Phylum	Class	Order	Family	Genus Species	Common Name	Type of sample
			Hygrobatidae	*Hygrobates* sp.	water mite	multiplate, van Veen
			Lebertiidae	*Lebertia* sp.	water mite	van Veen
			Limnesiidae	*Limnesia* sp.	water mite	multiplate, van Veen
			Unionicolidae	*Unionicola* sp.	water mite	van Veen

Table 6. Epibenthic community: number of species found within each major taxonomic group at each of the 12 multiplate sampler locations

Station #	**LWG01**	**LWG02**	**LWG05**	**LWG09**	**LWG06**	**LWG10**	**LWG08**	**LWG03**	**LWG04**	**LWG07**	**LWG11**	**LWG12**
LWG #	**08R034**	**08R033**	**06R028**	**04R026**	**06R027**	**03R030**	**04R025**	**09R027**	**07R024**	**05R020**	**09R028**	**13R001**
Station Type	**Off Channel**	**Off Channel**	**Off Channel**	**Off Channel**	**Channel**	**Channel**	**Channel**	**Channel**	**Channel**	**Channel**	**Ref.**	**Ref.**
Chironomids (midge)	10	10	11	11	12	16	17	13	16	10	13	13
Crustaceans	2	2	3	3	2	3	4	2	3	2	3	2
Oligochaetes	5	4	5	5	4	7	8	7	5	4	6	6
Trichoptera (caddisfly)	3	3	4	2	4	3	2	3	2	3	4	3
Flatworms	1	1	1	1	1	1	1	1	1	1	1	1
Nematodes	1	1				1				1		
Polychaetes					1	1	1		1	1		
Mites				1		1	1	1	2	1		
Bivalves			1	1	1	1	1	1	1		1	1
Gastropods	1			1	1	1	1	1		1		
Nemertea						1						
Major Taxonomic Groups	**7**	**6**	**6**	**8**	**8**	**11**	**11**	**8**	**8**	**9**	**7**	**6**
Total Richness (# of taxa present)	**23**	**21**	**25**	**25**	**26**	**36**	**36**	**29**	**31**	**24**	**26**	**26**

Table 7. Epibenthic community: mean number of individuals from each taxonomic group found on multiplate samplers at each of 12 stations (n=5)

Station #	**LWG01**		**LWG02**		**LWG05**		**LWG09**		**LWG06**		**LWG10**		**LWG08**		**LWG03**	
LWG #	**08R034**		**08R033**		**06R028**		**04R026**		**06R027**		**03R030**		**04R025**		**09R027**	
Station Type	**Off Channel**		**Off Channel**		**Off Channel**		**Off Channel**		**Channel**		**Channel**		**Channel**		**Channel**	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Common Taxa																
Chironomids (midges)	573.0	16.2	235.2	15.1	215.8	4.6	194.0	49.5	144.0	11.9	150.4	17.3	93.4	3.5	129.8	15.0
Crustaceans	0.4	0.2	22.0	4.2	36.6	4.5	84.6	11.0	223.8	30.1	36.6	5.1	231.0	17.9	234.7	36.6
Oligochaetes	598.2	55.9	81.6	28.2	172.0	53.6	508.0	153.8	280.6	68.8	384.8	73.0	84.8	22.6	275.1	41.4
Caddisflies	2.6	0.9	1.4	0.6	12.4	2.9	1.8	0.8	4.4	0.8	3.1	1.5	1.0	0.8	2.7	0.4
Flatworms	9.8	4.3	0.6	0.6	3.0	0.8	6.2	3.3	20.1	10.6	8.7	2.7	0.6	0.2	8.7	2.7
Uncommon Taxa																
Nematodes	0.4	0.4	0.2	0.2							0.9	0.7				
Polychaetes									4.0	4.0	0.3	0.3	0.2	0.2		
Mites							0.2	0.2			0.2	0.2	0.2	0.2	0.3	0.3
Bivalves					0.2	0.2	0.2	0.2	4.3	1.3	5.1	3.1	6.2	1.8	0.7	0.5
Gastropods	1.4	1.4					0.2	0.2	0.2	0.2	5.1	3.4	0.2	0.2	1.1	0.3
Nemertea											0.2	0.2				
Mean Abundance (per sampler)	**1,185.8**		**341.0**		**440.0**		**795.1**		**681.4**		**603.2**		**417.6**		**653.0**	
Mean Abundance per area (m^{-2})	**10,222**		**2,939**		**3,793**		**6,854**		**5,874**		**5,200**		**3,600**		**5,629**	

Station #	**LWG04**		**LWG07**		**LWG11**		**LWG12**	
LWG #	**07R024**		**05R020**		**09R028**		**13R001**	
Station Type	**Channel**		**Channel**		**Ref: Back**		**Ref: Chan**	
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.
Common Taxa								
Chironomids (midges)	209.9	21.5	97.6	10.1	110.5	14.9	169.8	26.7
Crustaceans	65.6	9.4	305.4	62.4	136.7	18.2	500.6	41.6
Oligochaetes	241.0	76.0	260.5	56.5	539.2	125.7	252.5	74.4
Caddisflies	4.2	1.7	1.4	0.7	4.2	1.3	4.4	2.7
Flatworms	4.6	2.6	8.6	3.5	0.7	0.5	4.5	1.9
Uncommon Taxa								
Nematodes			0.4	0.4				
Polychaetes	0.3	0.3	5.6	4.4				
Mites	0.4	0.2	0.2	0.2				
Bivalves	2.0	1.0			0.3	0.3	1.2	1.2
Gastropods			0.4	0.4				
Nemertea								
Mean Abundance (per sampler)	**527.9**		**680.0**		**756.6**		**933.0**	
Mean Abundance per area (m^{-2})	**4,551**		**5,862**		**5,611**		**8,042**	

4.2 Infaunal Community

Forty-four taxa representing 6 phyla, 10 classes, 16 orders, and 24 families were collected in sediments from the 21 stations processed in the ISA (Table 5). Dipterans (true flies) and oligochaetes were the most diverse taxonomic groups represented with 10 and 12 taxa, respectively. All dipterans present were members of the chironomid family (midges) while two orders and four families of oligochaetes were present. Other taxa found were bivalves, crustaceans, arachnids (mites and water mites), nematodes, polychaetes, and trichopterans (caddisflies). The complete list of organisms identified from each sample is available from Windward Environmental LLC.

Chironomids, oligochaetes, and bivalves were the most common taxonomic groups found. Chironomids were found in all 21 samples while oligochaetes and bivalves were present in 20 and 19 samples, respectively. Abundance varied greatly between samples, but oligochaetes, on average, were the most abundant.

Taxonomic richness varied by more than a factor of 3 and is presented in Table 8. Sample stations 06R002, 02R001, and 04R004 had the highest richness with 21, 19, and 19 taxa identified from each sample, respectively. All three stations were co-located sediment stations in relatively shallow water. The stations with the lowest richness were stations 09R041, 09R001, and 03R005. All three had 6 taxa only. Stations 09R001 and 03R005 were co-located sediment stations while station 09R041 was a channel site.

Abundance of organisms varied widely across stations (Table 9). There was a difference of two orders of magnitude between the station with the highest abundance and the station with the lowest abundance. The greatest total abundance of organisms was found at stations 08R001 and 06R040. The community at station 08R001 was almost entirely composed of oligochaetes (48% of the community) and chironomids (50% of the community). The most abundant taxa at station 06R040, oligochaetes and bivalves, made up fewer than 80% of the station's community. The most depauperate communities were found at stations 03R005 and 09R001. Only 7 organisms were collected at station 03R005; 38 were collected at station 09R001.

Table 8. Infaunal community: number of species found within major taxonomic groups at each van Veen sample station

Station #	02R001	03R005	03R040	03R041	04R003	04R004	05R003	05R041	06R001	06R002	06R040	07R003	07R040	08R001	08R003	08R040	08R041	09R001	09R002	09R040	09R041
Oligochaetes	6	1	2	5	5	5	4	5	5	6	3	6	5	4		5	5	4	5	5	3
Chironomids (midges)	3	1	2	1	3	5	5	2	4	5	4	2	1	3	2	3	1	2	5	2	2
Bivalves	1	1	2	1	2	2	2	1		2	2	1	1	2	2	1	1		2	1	1
Crustaceans	2	1	1		2	1	1	1		2	1			3	2				1	1	
Arachnids (mites)	4	2	1		1	4				2	2			2	1	2				1	
Polychaetes	1		2	1	1					1	1	1	1						2		
Nematodes	1			1	1	1			1	1	1			1	1	1	1		1		
Platyhelminthes									1												
Nemerteans			1								1										
Hirudinea (leeches)	1			1															1		
Odonata (dragonflies)					1					1											
Trichoptera (caddisflies)			1			1				1											
Total Richness	**19**	**6**	**12**	**10**	**16**	**19**	**12**	**9**	**11**	**21**	**15**	**10**	**8**	**15**	**8**	**12**	**8**	**6**	**17**	**10**	**6**

Table 9. Infaunal community: number of individuals from each taxonomic group at each of the 21 van Veen sample stations

Station #	02R001	03R005	03R040	03R041	04R003	04R004	05R003	05R041	06R001	06R002	06R040	07R003	07R040	08R001	08R003	08R040	08R041	09R001	09R002	09R040	09R041
Oligochaetes	53	1	40	88	96	88	93	67	94	65	203	300	52	345		152	79	32	236	249	108
Chironomids (midges)	9	1	5	26	5	107	20	15	48	186	43	4	30	358	3	52	32	6	18	28	4
Bivalves	51	1	53	9	26	10	32	43		80	258	5	3	13	6	9	5		9	13	5
Crustaceans	16	1	11		5	10	1	1		4	54			3	149				7	1	
Arachnids (mites)	13	3	1		1	4				4	2			2	1	2				1	
Polychaetes	5		65	1	12					3	20	1	1						2		
Nematodes	18			5	1	10			7	4	7			1	3	2	1		1		
Platyhelminthes									1												
Nemerteans			1								3										
Hirudinea (leeches)	1			8															2		
Odonata (dragonflies)					2					1											
Trichopterans (caddisflies)			11			5				2											
Total Abundance (per sample)	**166**	**7**	**187**	**137**	**148**	**234**	**146**	**126**	**150**	**349**	**590**	**310**	**86**	**722**	**162**	**217**	**117**	**38**	**275**	**292**	**117**
Total Abundance per area (m^2)	**1,660**	**70**	**1,870**	**1,370**	**1,480**	**2,340**	**1,460**	**1,260**	**1,500**	**3,490**	**5,900**	**3,100**	**860**	**7,220**	**1,620**	**2,170**	**1,170**	**380**	**2,750**	**2,920**	**1,170**

5.0 CONCLUSIONS

The invertebrate community collected on the multiplate samplers suggests that the epibenthic community in the ISA is more diverse and more abundant than the infaunal invertebrate community. The total number of taxa collected on the multiplate samplers was greater than in the van Veen grab samples. Also, the richness and abundance for each sample was larger on the multiplates than in the grab samples even though both sampled similar surface areas (approximately 0.1 m^2). Richness and abundance also varied less across multiplate sample stations than the grab stations.

The organisms collected during the infaunal and epibenthic surveys conducted by the LWG were consistent with the type of species expected for a deep, pelagic river like the Lower Willamette. According to the River Continuum Concept, the invertebrate community in deep rivers is likely to be dominated by the collector feeding group (Vannote et al. 1980). Collectors include both gatherers, organisms that forage for organic matter in the sediments, and filterers, organisms that filter organic matter out of the water column (Cummins and Klug 1979). The dominant taxa in the infaunal and epibenthic communities (oligochaetes and chironomids) collected in the LWR belong to the collectors feeding group.

6.0 REFERENCES

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Subattachment B1A: Epibenthic Sampling Field Report

1.0 MULTIPLATE DEPLOYMENT (JULY 15–16, 2002)

July 15, 2002
Weather conditions: clear, calm, warm

Shannon Pierce (SP, Windward) and Pam Sparks (PS, Striplin) remained on shore (at the Swan Island boat ramp and the St John's boat ramp) assembling and labeling all the components of the arrays to be deployed on this day.

Station 2 (08R033)
09:30

Frank Dillon (FD, Windward) and Bob Complita (BC, Windward) deployed 3 arrays along the north shore of Swan Island Lagoon, west of the Coast Guard station.

Station 1 (08R034)
10:30

FD and BC deployed 3 arrays along the southern end of the western shore of Swan Island Lagoon.

Station 5 (06R028)
11:50

FD, BC, and Derek Pelletier (DP, Windward) deployed 3 arrays between pilings along the southern shore of Willamette Cove.

Station 4 (07R024)
13:45

BC and DP deployed 3 arrays on the western shore of the main channel of the Willamette, north of the northernmost Atofina pier.

Station 6 (06R027)
14:40

BC and DP deployed 3 arrays along the eastern shore of the main channel, at the northern tip of Willamette Cove.

Station 7 (05R020)
15:10

BC and DP deployed 3 arrays along the eastern shore of the main channel, north of the St. John's Bridge.

Array A was placed in shallower water than arrays B and C (~5-10 feet shallower).

Off the river for the day by 14:00.

July 16, 2002
Weather conditions: clear, calm, warm

PS and SP remained on shore at the St. John's boat ramp assembling and labeling all the components of the arrays to be deployed this day.

Station 9 (04R026)
10:45

DP and BC deployed 3 arrays on the eastern shore of the Terminal 4 lagoon (just north of the main slip).

Array B has a wrongly labeled set of white, flotation buoys. They are labeled as 8-B rather than 9-B. The array B multiplate samplers are labeled correctly.

Station 8 (04R025)
11:05

DP and BC deployed 3 arrays on the western shore of the main channel, just off of the GATX property.

Arrays at Station 8

Station 10 (03R030)
12:00

DP and BC deployed 3 arrays on the western shore of the main channel,

between a helper barge and the shore near the Schnitzer property.

Station 3 (09R027)
14:30

DP and BC deployed 3 arrays along the eastern shore of the main channel, just south of the freighters and barges docked at Swan Island.

Station 11 (09R028)
15:00

DP and BC deployed 3 arrays along the eastern shore of the main channel, just south of the ISA. Water was quite shallow in the area so arrays were deployed ~50 yards off shore.

Station 11 is a reference station. The nearby shore is largely sandy beach.

Arrays at station 11 (reference)

Station 12 (13R001)

16:15

DP and BC deployed 3 arrays along the western shore of the main channel, just south of the I-5 bridge and north of pilings.

Station 12 is a reference station. The nearby shore is mostly riprap and unclassified fill.

Off the river for the day by 16:45.

Arrays at station 12 (reference)

2.0 MULTIPLATE RETRIEVAL (AUGUST 27-28, 2002)

August 27, 2002
Weather conditions: clear, calm, hot

DP, PS, and SP remained in the fish processing laboratory (located at Atofina Chemicals) to process the samplers once they were retrieved.

FD, BC, and Kim Gould (KG, Fishman) worked on the boat, retrieving the samplers.

Station 4 (07R024)
09:25 arrived at station

Array C (LWG-04-C-MP) was retrieved for benthic community analysis. It was the furthest upstream of the 3 arrays. Multiplate (MP) 01, 02, 03, 04, and 06 were kept and preserved in alcohol for analysis.

MP 05 was missing. MP 07 was not preserved, quota of 5 multiplate samplers was filled.

Array A (LWG-04-A-MP) was retrieved for tissue analysis. It was the middle array of the 3 arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array B (LWG-04-B-MP) was collected as an extra array. It was the most downstream array and was not needed since the other 2 arrays were still present. Six multiplate samplers were retrieved, one was missing.

10:05 left the station

Station 5 (06R028)
10:10 arrived at station

Array A (LWG-05-A-MP) was retrieved for benthic community analysis. It was the middle array of the 3 arrays. MP 05, 03, 01, 07, and 06 were kept and preserved in alcohol for analysis.

MP 04 was missing. MP 02 was not preserved, quota was filled.

Array B (LWG-05-B-MP) was retrieved for tissue analysis. It was the furthest upstream of the 3 arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array C (LWG-05-C-MP) was collected as an extra array. It was the most downstream array and was not needed since the other 2 arrays were still present. Six multiplate samplers were retrieved, one was dropped.

10:40 left the station.

Station 6 (06R027)
12:30 arrived at station

Array B (LWG-06-B-MP) was retrieved for benthic community analysis. It was the most upstream of the arrays. MP 05, 03, 02, 01, and 04 were kept and preserved in alcohol for analysis.

MP 07 and 06 were retrieved but not preserved, quota was filled.

Array C (LWG-06-C-MP) was retrieved for tissue analysis. It was the most downstream of the arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array A (LWG-06-A-MP) was missing, but was not needed. It was found vandalized and pulled up on the shore in Willamette Cove. The sample was not used.

13:10 left the station.

FD departed for Seattle, leaving KG and BC in the boat.

Station 7 (05R020)
13:15 arrived at station.

Array B (LWG-07-B-MP) was retrieved for benthic community analysis. It was the middle of the three arrays. MP 04, 05, 06, 01, and 03 were kept and preserved in alcohol for analysis.

MP 02 and 07 were retrieved but not preserved, quota was filled.

Array C (LWG-07-C-MP) was retrieved for tissue analysis. It was the most downstream of the 3 arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array A (LWG-07-A-MP) was collected as an extra array. It was the most upstream array and was not needed since the other 2 arrays were still present. All 7 multiplate samplers were retrieved.

14:10 left the station.

Station 12 (13R001)
15:20 arrived at station.

Array A (LWG-12-A-MP) was retrieved for benthic community analysis. It was the most upstream of the 3 arrays. MP 03, 02, 01, 07, and 06 were kept and preserved in alcohol for analysis.

MP 04 and 05 were retrieved but not preserved, quota was filled.

Array B (LWG-12-B-MP) was retrieved for tissue analysis. It was the middle of the three arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array C (LWG-12-C-MP) was collected as an extra array. It was the most downstream array and was not needed since the other 2 arrays were still present. All 7 multiplate samplers were retrieved.

16:05 left the station.

Station 11 (09R028)
16:20 arrive at station

Array C (LWG-11-C-MP) was retrieved for benthic community analysis. It was the most downstream of the 3 arrays. MP 06, 01, 04, 05, and 07 were kept and preserved in alcohol for analysis.

MP 03 and 02 were retrieved but not preserved, quota was filled.

Array A (LWG-11-A-MP) was retrieved for tissue analysis. It was the most upstream of the three arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array B (LWG-11-B-MP) was collected as an extra array. It was the most upstream array and was not needed since the other 2 arrays were still present. All 7 multiplate samplers were retrieved.

17:00 left the station, off the river for the day.

August 28, 2002
Weather: clear, calm, hot

BC and SP remained in the lab processing the samples that were retrieved. DP and KG were in the boat collecting the samplers.

Station 10 (03R030)
09:00 arrived at station

Array A (LWG-10-A-MP) was retrieved for benthic community analysis. It was the most upstream of the 3 arrays. MP 01, 04, 05, 06, and 07 were kept and preserved in alcohol for analysis.

MP 03 and 02 were retrieved but not preserved, quota was filled.

Array B (LWG-10-B-MP) was retrieved for tissue analysis. It was the most downstream of the three arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array C (LWG-10-C-MP) was collected as an extra array. It was the middle array and was not needed since the other 2 arrays were still present. All 7 multiplate samplers were retrieved.

09:35 left the station.

Station 8 (04R025)
09:40 arrived at station.

Array A (LWG-08-A-MP) was retrieved for benthic community analysis. It was the most upstream of the 3 arrays. MP 03, 04, 05, 06, and 07 were kept and preserved in alcohol for analysis.

MP 01 and 02 were retrieved but not preserved, quota was filled.

Array C (LWG-08-C-MP) was retrieved for tissue analysis. It was the most downstream of the three arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array B (LWG-08-B-MP) was collected as an extra array. It was the middle array and was not needed since the other 2 arrays were still present. All 7 multiplate samplers were retrieved.

10:25 left the station.

Station 9 (04R026)
10:30 arrived at station

Array C (LWG-09-C-MP) was retrieved for benthic community analysis. It was the most upstream of the 3 arrays. MP 02, 01, 04, 05, and 07 were kept and preserved in alcohol for analysis.

MP 03 and 06 were retrieved but not preserved, quota was filled.

Array A (LWG-09-A-MP) was retrieved for tissue analysis. It was the middle of the three arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array B (LWG-09-B-MP) was collected as an extra array. It was the most downstream array and was not needed since the other 2 arrays were still present. All 7 multiplate samplers were retrieved.

11:15 left the station

Station 1 (08R034)
13:20 arrived at station.

The arrays were located amidst the pilings and were difficult to retrieve.

Array B (LWG-01-B-MP) was retrieved for benthic community analysis. It was the southernmost of the 3 arrays. MP 02, 03, 04, 06, and 07 were kept and preserved in alcohol for analysis.

MP 05 was missing. MP 01 was not preserved, quota was filled.

Array A (LWG-01-A-MP) was retrieved for tissue analysis. It was the middle of the three arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array C (LWG-01-C-MP) was collected as an extra array. It was the most northern array and was not needed since the other 2 arrays were still present. All 7 multiplate samplers were retrieved.

14:15 left the station.

Station 2 (08R033)
14:30 arrived at station.

Array A (LWG-02-A-MP) was retrieved for benthic community analysis. It was the easternmost of the 3 arrays. MP 02, 01, 03, 05, and 07 were kept and preserved in alcohol for analysis.

MP 06 and 04 were retrieved but not preserved, quota was filled.

Array B (LWG-02-B-MP) was retrieved for tissue analysis. It was the middle of the three arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array C (LWG-02-C-MP) was collected as an extra array. It was the westernmost of the three arrays and was not needed since the other 2 arrays were still present. Six multiplate samplers were retrieved, MP07 was missing.

15:00 left the station.

Station 3 (09R027)
16:20 arrived at station

Array B (LWG-03-B-MP) was retrieved for benthic community analysis. It was the most downstream of the 3 rays. MP 01, 03, 04, 05, and 07 were kept and preserved in alcohol.

MP 02 and 06 were retrieved but not preserved, quota was filled.

Array A (LWG-03-A-MP) was retrieve for tissue analysis. It was the most upstream of the arrays. All 7 multiplate samplers were retrieved for tissue analysis.

Array C (LWG-03-C-MP) was collected as an extra array. It was the middle of the three arrays and was not needed since the other 2 arrays were still present. All 7 multiplate samplers were retrieved.

17:00 left the station, off the river for the day.

Attachment B2: Aquatic Plant and Amphibian/Reptile Reconnaissance Survey

1.0 INTRODUCTION

Few data exist on the aquatic plant community and the presence of amphibians and reptiles along the Lower Willamette River (LWR) in the initial study area (ISA). To further develop the Portland Harbor Conceptual Site Model, a better understanding is needed of significant and complete exposure pathways. Therefore, an aquatic plant and amphibian/reptile reconnaissance level survey was conducted on June 26-28, 2002 to determine the presence or absence of these species throughout the ISA. As specified in the Round 1A Sampling and Analysis Plan (SAP) (Striplin 2002), this reconnaissance survey will be used to determine whether aquatic plants, amphibians or reptiles should be included in the ecological risk assessment. This study was designed to be a qualitative survey to determine presence/absence of amphibians/reptiles and plants in the ISA. However, the presence of some amphibians may not have been recorded due to the survey being performed in late June after the hatching of egg masses. This study was not meant to be a quantitative estimation of amphibian/reptile or plant abundance or a quantitative survey of available amphibian/reptile or plant habitat.

2.0 OBJECTIVES

There were three objectives of the reconnaissance survey:

- To determine the presence or absence of amphibians and/or reptiles in the ISA by surveying potential amphibian and reptile habitat for evidence of amphibians or reptiles (e.g. egg masses, tadpoles, mature frogs or reptiles)
- To determine the presence or absence of aquatic plants throughout the ISA by locating potential areas of aquatic plant establishment and surveying these areas for submersed and emergent macrophytes
- To determine if aquatic plants, amphibians, and reptiles should be included in the ecological risk assessment and if so, what are the likely areas within the ISA where significant and complete exposure pathways exist

3.0 METHODS

Aquatic plant and amphibian/reptile surveys were conducted at twenty-one sampling sites located throughout the ISA. Sampling locations were selected based on bank condition and amphibian/reptile habitat quality. The majority of the sampling locations were selected before going out in the field and were selected to ensure that

all representative bank conditions in the ISA were sampled at least twice. The most common bank types occurring in the ISA were riprap, unclassified fill, natural bank and river beach, and seawall (Figure 1). Many sampling sites coincided with the presence of in-water or shoreline structures that were considered to represent possible habitat. In addition, all designated habitat areas in the ISA identified by the Willamette River Inventory (Adolfson et al. 2000) were included in the survey (e.g. Harborton Forest and Wetlands and Willamette Cove). Approximately one third of the sample locations were selected while in the field based on visual observations of potential aquatic plant and amphibian/reptile habitat.

Surveys were conducted June 26 through June 28, 2002. At each sampling site, the location coordinates were recorded using GPS (Magellan GPS ColorTRAK). A general site description of the bank conditions, including slope of the bank, substrate, and presence of upland vegetation, was also recorded. Digital photos were taken at each site (Subattachment B2A). A set time period of 30-45 minutes was spent at each site identifying plant species and looking for evidence of amphibians and reptiles according to the methods described below. This time period defined the area sampled at each site.

3.1 Aquatic plant survey

The plant survey focused on identifying submersed and emergent aquatic plant communities in the ISA. The methods for surveying the submersed plant community were based on the *Washington Department of Ecology Aquatic Plant Sampling Protocol* (Parsons 2001). Since the turbidity of the LWR made it difficult to visually assess the submersed plant community, a sampling rake was used to assess the presence of submersed plants at each sampling location. This rake was constructed from a thatch rake, also known as a double-sided rake. The rake handle was cut off and a 15-m rope was tied to the head of the rake. The rake was tossed overboard into the water approximately 4.5-6.0 m from shore at an approximate depth range of 2.4-3.0 m. The rake was dragged across the substrate surface for approximately 2.0-3.0 m and retrieved to collect any plants. Any plant material collected by the rake was inspected for submersed plant species. The depth of each throw was recorded and a general description of the relative rate of flow, turbidity, and substrate was also recorded.

The emergent plant community was surveyed in line transects approximately 15-20 m in length that ran parallel to the shore. This survey included plants growing in water and plants growing on the shore that may be exposed to high water. Only species that were growing within a noticeable high-water mark on shore (e.g. obvious sedimentation) were included. The width of the transect ranged from 5-15 m perpendicular to the water, depending on the slope of the site. Approximately 30-45 minutes were spent at each site observing and identifying plants. Most plants were identified to the species level; however, grass and sedge species that did not

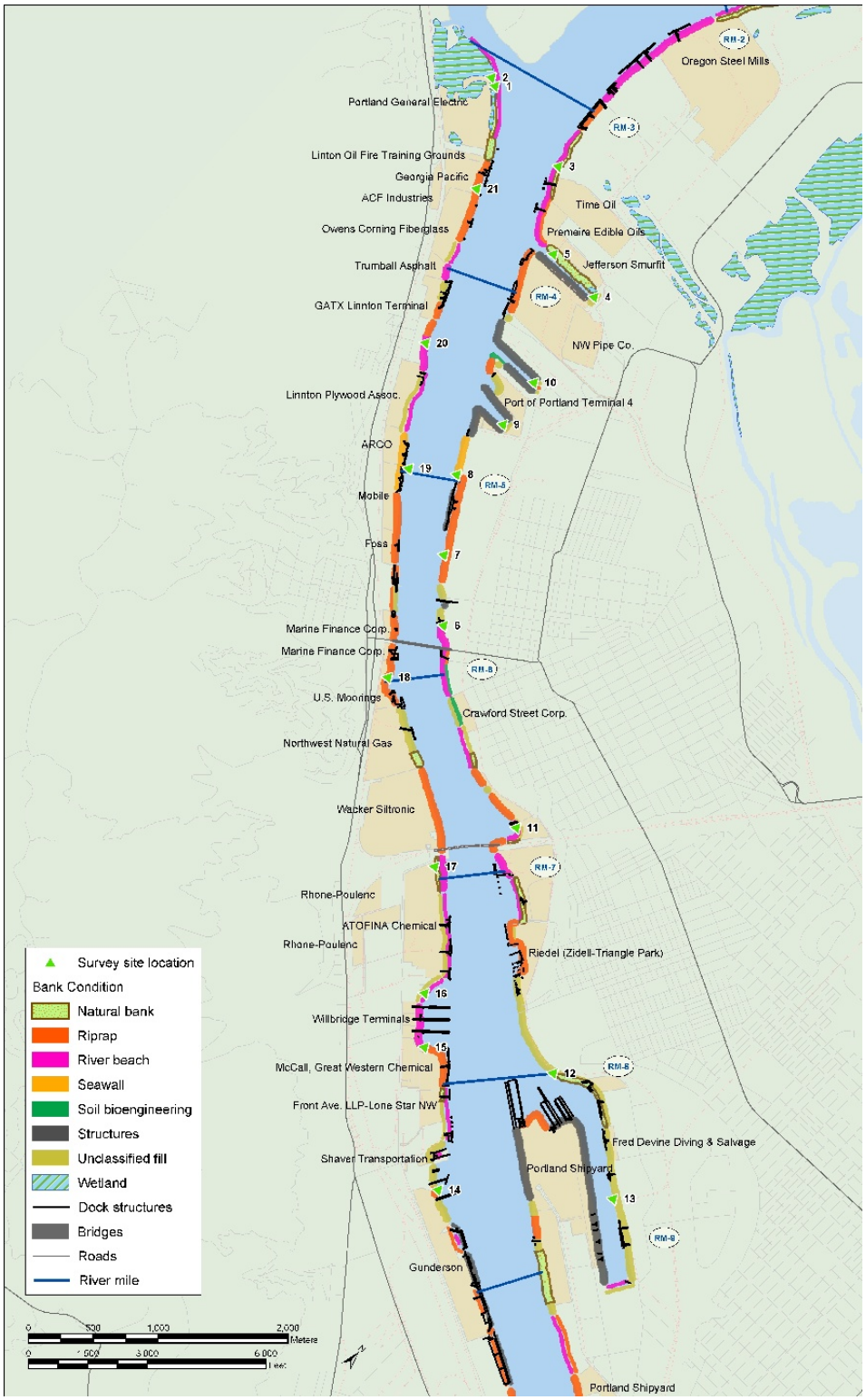

Figure 1. Lower Willamette River aquatic plant and amphibian/reptile survey site locations

have any flowering structures present were identified to the genus level. Any common plants that were not identified at the site were collected and identified later with the help of plant identification guidebooks (Cooke 1997; Guard 1995; Hitchcock and Cronquist 1973) and a local plant expert, Toni Pennington (2002). A general description of the location was recorded and included substrate, relative bank slope, and depth of water where the emergent vegetation furthest from shore was located.

3.2 Amphibian and reptile survey

The amphibian and reptile survey focused on identifying amphibian/reptile presence by locating adult or juvenile amphibians/reptiles visually or auditorily or by locating amphibian egg masses. The methods employed for visually locating amphibians/reptiles or egg masses were based on the methods of Heyer et al. (1994) and discussions with amphibian expert, James Word (2002). At each sampling location, two bank transects were surveyed by walking approximately 15-20 m, turning over rocks, looking in and under logs, and searching through vegetation. A strip extending approximately 0.3 m from either side of the transect line was also surveyed. The first transect was located parallel to the water line, at the water line. During this transect a small, fine mesh net was used to sample shallow waters and pool areas for presence of tadpoles and egg masses. The second transect was conducted approximately one meter from the high water line. Approximately 30-45 minutes were spent at each sampling site, looking for evidence of amphibian/reptile presence. At each site, notes were taken in a field notebook to record evidence of amphibians/reptiles observed and the location description of any evidence found. If possible, pictures were taken of amphibians/reptiles observed. Observed amphibian/reptiles were identified in the field using a field guide (Corkran and Thoms 1996) and then identifications were confirmed by examination of the pictures taken by an amphibian expert, James Word. In addition to the daytime visual survey, nighttime frog call methods were tested after sunset on 6/26/02. Three locations in the ISA (Site 1, 12, and 13) were sampled by the following methods:

- Positioning research vessel as close to shore as possible, without anchoring, and turning off engine to allow for a few minutes of silence
- Playing a CD recording (Davidson 1995) of frogs calling for approximately 1 minute for each type of frog call used[1]
- Listening for approximately 2 minutes between each type of recording for responses from amphibians present
- Repeating the above two steps

[1] Frog call recordings were a chorus of red-legged frogs and Pacific tree frogs and a chorus of bullfrogs.

The sampling location and any responses obtained were recorded in the field notebook. These methods were only employed for one night, as it was found that more results were gained by the daytime visual survey; however, restricting surveying to daytime-only may have resulted in limited evidence on the presence of adults, which are generally inactive during the day. Auditory surveys are typically successful during the breeding season, which for common species in this system (e.g. red-legged frogs, bullfrogs, and Pacific tree frog) would occur in late winter or early spring (Corkran and Thoms 1996). The success of this auditory survey may have been limited due to its timing in late June. All methods used were consistent with commonly employed methods for reconnaissance level surveys (Hendricks and Reichel 1998; National Parks Assoc. of NSW and NSW National Parks and Wildlife Service 2001).

4.0 RESULTS

In general, the four bank conditions on which the majority of the sampling sites were located included riprap, unclassified fill, natural bank, and river beach due to the occurrence of available habitat in these areas. Other more developed bank types such as seawall and over-water structures were also visited, but did not support aquatic plant communities, and therefore did not provide suitable amphibian or reptile habitat. Results of the plant and amphibian/reptile surveys are presented in Table 1. This table includes a physical description of each site and the plants, amphibians, and reptiles observed. The survey looked for evidence of salamanders but none was found. It was not possible to identify the species of the egg masses.

Table 1. Summary results of reconnaissance survey

Site	Latitude (N)	Longitude (W)	Site Description	Dominant Plant Type	Amphibians/ Reptiles Observed?
1	45 37 03	122 47 47	Upland natural bank drops off sharply to low sloping vegetated beach and shallow water. Patches of emergent vegetation occurred from waterline to 11in. of water. Contains small still water habitats among emergent vegetation.	Reed canary grass*, purple loosestrife*, alfalfa, sedges*, common horsetail	no
2	45 37 04	122 47 50	Upland natural bank drops off sharply to low sloping vegetated beach and shallow water. Large patches of emergent vegetation occurred from waterline to 0.8 m of water. Contains small still water habitats among emergent vegetation. Much woody debris.	Reed canary grass*, common rush*, horsetail, sedges*, water moss, red osier dogwood*, bird's foot trefoil	2 Northern red-legged frog
3	45 36 59	122 47 11	Upland natural bank drops off to low sloping sandy beach. Much woody debris. No emergent vegetation present.	Columbia river willow*, reed canary grass*	1-Northern red-legged frog

Site	Latitude (N)	Longitude (W)	Site Description	Dominant Plant Type	Amphibians/ Reptiles Observed?
4	45 36 41	122 46 30	Steep highly vegetated natural bank that drops off quickly into deeper water. Narrow strip of emergent vegetation present from edge of bank to 0.8 m of water.	Cattail*, reed canary grass*, sedges*, bird's foot trefoil, yellow water-flag iris*, common rush*	egg mass
5	45 36 42	122 46 51	Steep riprapped bank with little woody debris and very few plants. No emergent vegetation present.	Himalayan blackberry	no
6	45 35 15	122 45 50	Low sloping sandy beach with some vegetation and woody debris. No emergent vegetation present.	Columbia river willow*	no
7	45 35 28	122 46 07	Steep riprapped bank that drops off quickly into deeper water. Sparsely vegetated with large woody debris. No emergent vegetation present.	Himalayan blackberry, reed canary grass*, St. John's wort	no
8	45 35 45	122 46 23	Seawall. No plants present at water's edge.		no
9	45 36 02	122 46 23	Steep rocky bank that is sparsely vegetated and drops off quickly into very deep water (4.5-6 m). No emergent vegetation present. Abundant large woody debris present on bank and floating near shore.	Himalayan blackberry, common velvet grass, St. John's wort	call-unidenti-fiable
10	45 36 15	122 46 25	Steep vegetated bank at end of slip that drops off quickly into deeper waters. Emergent vegetation present in narrow band at edge of bank.	Reed canary grass*, grass spp., common rush*, cattail*, sedges*, St. John's wort	egg mass
11	45 34 50	122 44 42	Low sloping sandy beach with some vegetation, woody debris, and concrete pilings. Emergent vegetation present at edge of rocky outcrop.	Black cottonwood, common rush*	no
12	45 34 11	122 43 33	Very steep rocky bank with large woody debris. Narrow strip of emergent vegetation in shallow water.	Oregon ash*, sedges*, smartweed*	no
13	45 33 58	122 42 47	Low sloping sandy beach with some vegetation and woody debris. Emergent vegetation present in shallow water. Abundant dead willow seedlings.	Smartweed*, red osier dogwood*, cattail*	call-Pacific tree frog
14	45 33 30	122 43 35	Narrow rocky outcrop extending out from steep bank. Narrow strip of shallow water, drops off quickly into deeper water. Few emergent plants.	Bird's foot trefoil, Himalayan blackberry, St. John's wort, oxeye daisy, Douglas' spiraea*	no

Site	Latitude (N)	Longitude (W)	Site Description	Dominant Plant Type	Amphibians/ Reptiles Observed?
15	45 33 54	122 44 13	Steep sandy beach with some large woody debris. No emergent vegetation present.	Himalayan blackberry, Scot's broom, common wetland asters*, common groundsel	no
16	45 34 04	122 44 26	Low sloping sandy beach adjacent to backwater marsh. Some large woody debris. No emergent vegetation present on beach except large trees. Additional backwater area with outfall has very steep banks that drop off quickly to deep waters. Few emergent plants are located on the fringe of this backwater area.	Oregon ash*, thistle, bird's foot trefoil, horsetails. *In marsh*: cattail*, common rush*, reed canary grass*. *In outfall area*: common rush*	no
17	45 34 29	122 44 54	Low sloping sandy beach with some large woody debris. Few emergent plants present at waterline and in shallow waters near shore.	smartweed*, purple loosestrife*, bird's foot trefoil	no
18	45 34 56	122 45 52	Steeply sloped riprap covered bank that drops off quickly to deeper waters. Abundant large woody debris. Very narrow shallow water habitat. No emergent vegetation present. Abundant vegetation present above high water line.	Himalayan blackberry, reed canary grass*, sweet clover, bird's foot trefoil, Scot's broom	no
19	45 35 38	122 46 37	Seawall with outfall.	Himalayan blackberry	no
20	45 36 04	122 47 03	Low sloping sandy beach with dense vegetation and some woody debris. Emergent vegetation, including live and standing dead plants, present in shallow water.	Reed canary grass*, Columbia river willow*	no
21	45 36 41	122 47 27	Steeply sloped riprap covered bank that drops off quickly to deeper waters. Some large woody debris. No emergent vegetation present. Some vegetation present above high water line.	Himalayan blackberry, willows	no

*Indicates aquatic plant species. See Table 2 for more detail.

4.1 Aquatic plant survey

This survey identified twenty-six plant species, most of which were obligate and facultative wetland plant species, as defined by the *National List of Plant Species That Occur in Wetlands* (Reed 1996; Table 2).

Table 2. List of plant species found in the LWR

Species[A]	Indicator Status [B]
Aster spp. (common wetland asters) [C]	FAC/FACW
Carex spp. (sedge)	FACW/OBL
Cirsium arvense (Canada thistle)*	FAC-
Cornus sericea (red-osier dogwood)	FACW
Cytisus scoparius (Scots broom)*	NOL
Dipsacus fullonum (teasel)*	FAC
Equisetum arvense (common horsetail)	FAC
Fontinalis antipyretica (water moss)	NOL
Fraxinus latifolia L. (Oregon ash)	FACW
Holcus lanatus L. (common velvet grass)*	FAC
Hypericum perforatum (St. John's wort)*	NOL
Iris pseudacorus (yellow water-flag iris)*	OBL
Juncus effusus (common rush)	FACW
Leucanthemum vulgare (oxeye daisy)*	NI (no indicator)
Lotus corniculatus (bird's foot trefoil)*	FAC
Lythrum salicaria (purple loosestrife)*	OBL
Medicago falcata L. (alfalfa)*	NOL
Melilotus alba Mill. (sweet clover)*	NOL
Phalaris arundinacaea (reed canary-grass)*	FACW+
Polygonum spp. (smartweed)	FACW/OBL
Populus balsamifera var. *trichocarpa* (black cottonwood)	FAC
Rubus discolor (Himalayan blackberry)*	FACU
Salix fluviatilis Nutt. (Columbia River willow)	OBL
Senecio vulgaris L. (common groundsel)*	FACU
Spiraea douglasii (Douglas' spiraea)	FACW
Typha latifolia (cattail)	OBL

[a] Exotic species are identified by * following the common name. [c] The Aster spp. were garden varieties not *Aster curtus* or *Aster vialis*.

[b] Indicator status refers to the likelihood of that species occurring in regional wetlands and are defined as follows:

- "Obligate Wetland (OBL). Occur almost always (estimated probability >99%) under natural conditions in wetlands.
- Facultative Wetland (FACW). Usually occur in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
- Facultative (FAC). Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
- Facultative Upland (FACU). Usually occur in non-wetlands (estimated probability 67%-99%), but occasionally found in wetlands (estimated probability 1%-33%).
- Obligate Upland (UPL). Occur in wetlands in another region, but occur almost always (estimated probability >99%) under natural conditions in non-wetlands in the region specified.
- Not on list (NOL). [This species is not included on the Reed (1996) list.]

A positive or negative sign denotes which end of the reported range of probability that species is likely to regionally occur." (Reed 1996) For example, the probability that reed canary grass (FACW+) occurs in Pacific Northwest wetlands is closer to 99% than 67%.

The aquatic plant community was dominated by emergent hydrophytes that are able to live with their roots in water or muddy substrates. No submersed plants were found offshore in waters 2.4-3 m deep; however, a few submersed plants were identified close to the waterline near shore. These submersed plants included water moss, grasses, and sedge species.

The 21 sites sampled in this survey can be separated into three major types of aquatic plant habitat: 1) rocky or riprapped banks dominated by scrub-shrub wetland vegetation; 2) sandy beach where no emergent macrophytes were present in the water; and 3) sandy or rocky banks with emergent macrophytes present in the water (Figure 2). Below is a brief description of each habitat type and the dominant plant species that occurred in each type.

4.1.1 Rocky or riprapped banks

The rocky or riprapped bank type was usually located on fairly steep banks with no or very narrow shallow water habitat present (Table 1, Figure 2). These areas were usually exposed to heavy wave action and strong currents. Usually, there were no emergent macrophytes present at these locations; however, a few sites did have a few grasses at the water's edge. Dominant plant species at these sites included Himalayan blackberry (exotic), Columbia River willow, and reed canary grass (exotic).

4.1.2 Sandy beaches with no emergent macrophytes

The sandy beach bank type with no emergent vegetation present was usually adjacent to steep uplands that were either riprapped or developed (Table 1, Figure 2). These bank types were frequently located in areas that were exposed to heavy wave action. In addition, relative current and turbidity of the river adjacent to these banks were frequently higher than more protected areas of the river. Plants were usually located 1 m or so upland from the waterline at these sites. Dominant plant species in this habitat type included Columbia River willow, Oregon ash, Himalayan blackberry (exotic), and common horsetail.

4.1.3 Sandy beaches with emergent macrophytes

The sandy or rocky bank habitat type with emergent vegetation present was a common occurrence along the main stem of the LWR in the ISA (Figure 2). Similar to the sandy beach bank type, these bank types were also adjacent to steep uplands; however, these banks were either of sandy or rocky substrate. These bank types were located in more protected areas in the ISA, such as at the end of slips or in Swan Island Lagoon (Table 1). Common emergent plant species included smartweed, sedges, common rush, and cattails. Red osier dogwood, reed canary grass (exotic), horsetail, and willows are other common species that occurred occasionally in water, but were more frequently located higher on the bank and may be water-covered during high water periods.

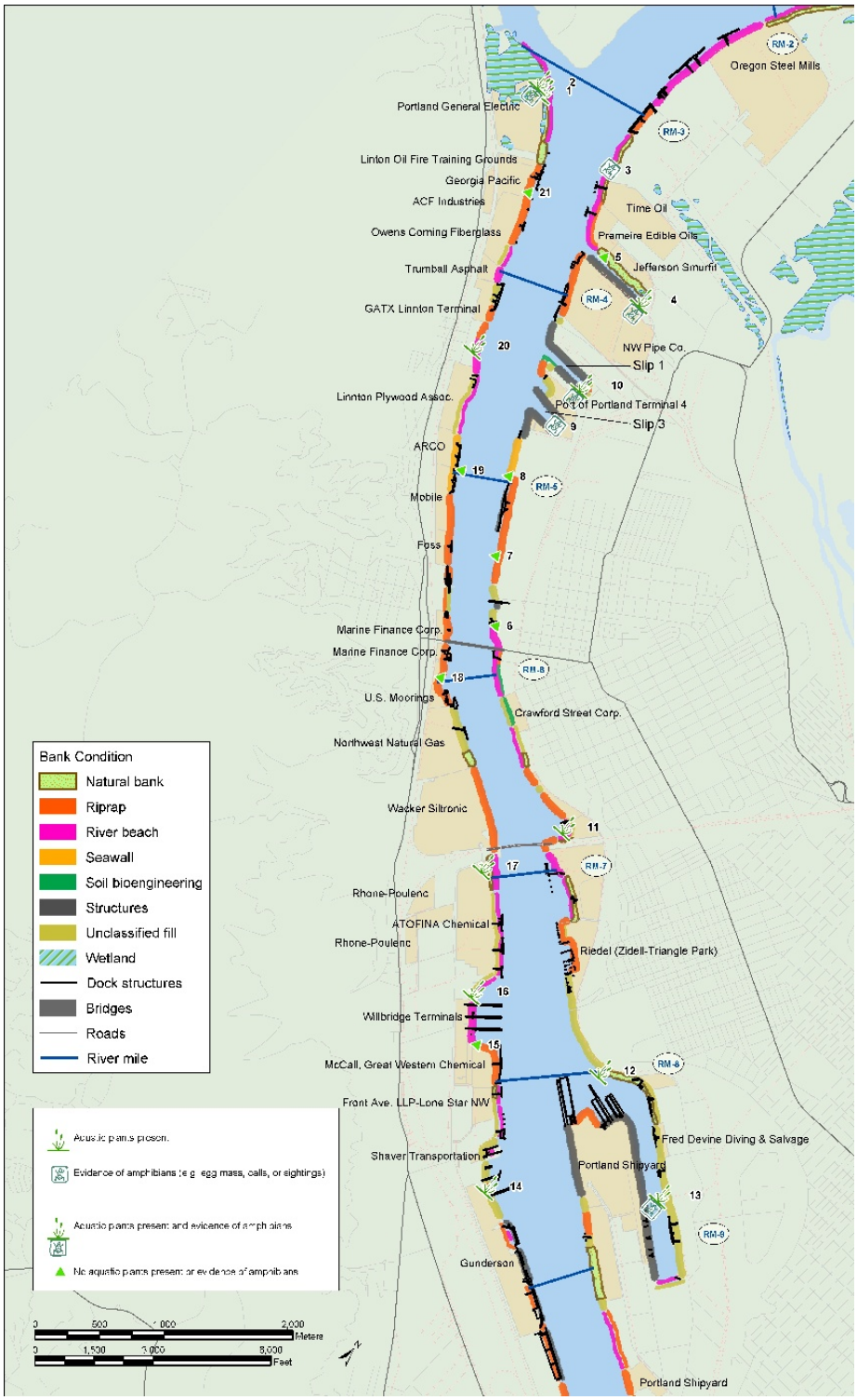

Figure 2. Location of aquatic plants and amphibians at survey sites in the lower Willamette River

4.1.4 Other types of sites

Three sampling sites did not fall into these three bank type categories. Site 12 was different from the rest of the sampling sites in that it was located at the edge of Waud Bluff at the northwestern shore of Swan Island Lagoon (Table 1, Figure 2). The upland of this sampling site was undeveloped, but very steep. The shoreline of this site was also very steep, and grass covered with a rocky substrate and a narrow shallow water area. Dominant plants at this site included Oregon ash and grass species. Also, a few sedge species and smartweed were growing in the shallow water habitat.

In addition, two seawall sites (Site 8 and 19) were included in this survey (Table 1, Figure 2). No shallow water habitat occurred at these sites and no submersed or emergent vegetation were observed at these sites. However, at Site 19, Himalayan blackberry was growing around an outfall in the seawall (see photo in Subattachment B2A).

4.2 Amphibian and reptile survey

Evidence of amphibian presence was observed at 6 of the 21 sampling locations (Figure 2, Table 1). No reptiles were found. The evidence of amphibian presence can be separated into the three major types of habitat identified and described in Section 4.1. In addition, frogs were heard calling in multiple habitat types, but not in response to the frog call recordings. Because no responses to the frog call recordings were heard, the nighttime frog call survey was terminated after the first night (6/26/02). However, surveying primarily during the day may have excluded evidence of the presence of adult amphibians. Below is a brief description of the evidence of amphibians that was found in each type. Figure 3 presents those areas where amphibian sensitive life stages may occur. While this survey supports the presence of amphibian species in the ISA in general habitat types, specific exposure areas were not defined in the ISA.

4.2.1 Rocky or riprapped banks

Evidence of amphibians were found at three sites characterized as rocky or riprapped banks. These sites were all located at the end of slips (Site # 4, 9, and 10; Figure 2) and were thus protected from heavy wave action. Amphibian egg masses were found among the emergent vegetation at the end of the Burgard Yard slip and Terminal 4 Slip 1 (Site 4 and 10). The very steep natural bank at the Burgard Yard was thickly vegetated with emergent vegetation (Photograph: Site 4.jpg). The habitat at Site 10 was also a very steep natural bank, however it was less densely vegetated. This site also had abundant floating woody debris (Photographs: Site 10a.jpg and Site 10b.jpg). Windward was not able to identify the egg mass to genus. A frog call was incidentally heard at the location inside Terminal 4 Slip 3 (Site 9). The call was not identifiable to genus, however.

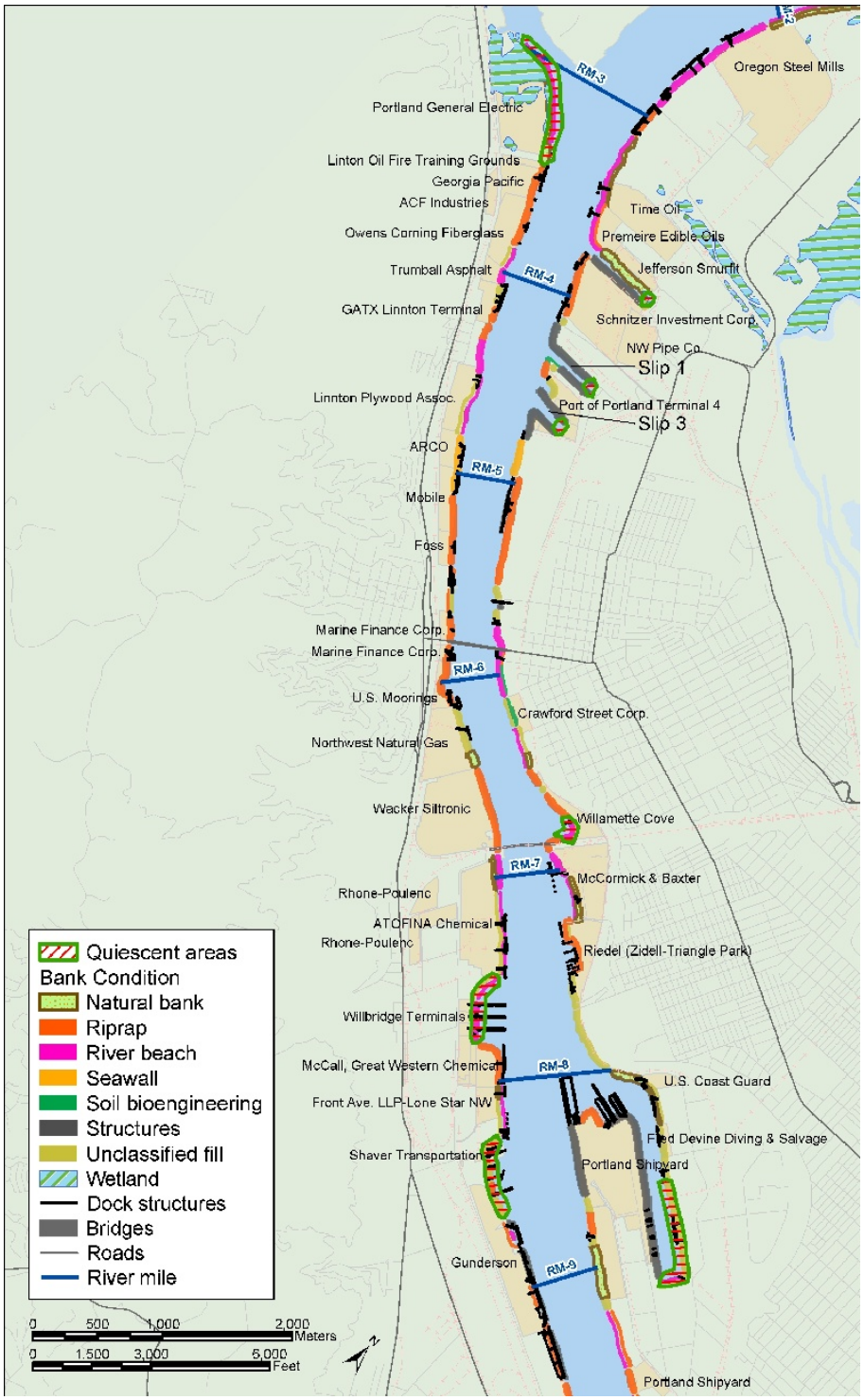

Figure 3. Areas that could potentially support amphibian sensitive life stages in the lower Willamette River

4.2.2 Sandy beaches with no emergent macrophytes

One northern red-legged frog (*Rana aurora*) was found at Site 3, which is characterized as sandy beach with no emergent vegetation present (Table 1, Figure 2). This location contained a large, gently sloping beach with considerable large woody debris stranded on the beach (Photograph: Site 3). The frog was found sitting on top of a large stranded log.

4.2.3 Sandy beaches with emergent macrophytes

Evidence of amphibians was found at one site characterized as sandy beach bank type with emergent vegetation present. Two northern red-legged frogs were found at Site 2, the Harborton Forest and Wetlands area (Table 1, Figure 2). This area has a low sloping beach with large woody debris and thickly vegetated uplands (Photograph: Site 2.jpg). The area is also protected from wave action by a large log raft anchored approximately 30-50 m from shore, which creates calmer water than other parts of the mainstem Willamette. This area also contains small areas of pooling water due to emergent vegetation and the undercut banks and large woody debris. One of the frogs observed was found on sedge in a small pool of water (Photograph: Site 2-Red-legged frog-a.jpg). The other frog found at this location was in a patch of St. Johns wort on the beach. The third red-legged frog was observed on the eastern side of the river.

4.2.4 Multiple habitat types (frog call survey results)

Frog calls were heard throughout the Swan Island Lagoon. One calling Pacific tree frog (*Hyla regilla)* was heard in the Lagoon during the 6/26/02 frog call survey (site 13, Figure 2). Other Pacific tree frogs were heard in the Lagoon on various occasions over the three sampling days. Pacific tree frogs live in diverse habitats (Corkran and Thoms 1996). Habitat in the Swan Island Lagoon is largely developed. The southern side of the Lagoon is made of industrial structures, docks, and moored vessels, which surround a small amount of sloping, bank habitat. The bank consists of small beach areas and unclassified fill with some vegetation. The northern side of the lagoon is bulkhead and there is no visible bank habitat. While visual surveys do not indicate the presence of amphibians, and identification of suitable amphibian habitat (such as terrestrial ponds and wet meadows) was extremely limited, the results of the audio survey indicate that some Pacific tree frogs may utilize the mainstem Willamette river habitat.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The presence of emergent macrophytes and visual or auditory accounts of amphibian presence suggest that amphibians and aquatic plant habitat are present in the ISA. With the exception of Site 8 (seawall), plants were present at every sampling site. However, many of these plants were emergent or plants more typical of disturbed upland areas. The high level of development and human activity in the ISA tend to favor disturbance-tolerant species. For example, many species were either invasive, exotic species such as reed canary grass and Himalayan blackberry, or native species

that are common in disturbed areas, such as cattails and common rush. In addition, emergent macrophytes were most often observed most often at protected areas on the river, such as at the end of the Burgard Yard slip, in Swan Island Lagoon, and in Willamette Cove. In contrast, emergent plants were not as common on rocky or riprapped banks, which supported a scrub-shrub plant community. The lack of submersed plants at some of the sites may be related to the water fluctuations and high turbidity of the navigational channel (Pennington 2002). Protected areas in the ISA appear to support more plants. This is likely due to the decreased wave action in these areas.

This survey suggests that habitat in the ISA can and does support an amphibian community. Amphibians appear to be especially prevalent in off-channel backwater areas. Amphibian presence was most often detected in areas with emergent vegetation, but emergent vegetation does not appear to be necessary for amphibian presence, as shown by the red-legged frog found at site 3. Figure 3 displays areas in the ISA that Windward believes have the potential to support amphibian breeding and rearing habitat based on the reconnaissance survey outlined in this report and knowledge of amphibian life history and habitat needs. These areas are characterized by calmer waters than the rest of the ISA because they are protected inside slips or other structures, contain some degree of aquatic vegetation, and contain beaches or natural banks. Reptiles were not observed in the ISA. The methods used to locate presence/absence are common survey techniques, however, absence of reptiles in this one survey does not indicate reptiles will never utilize the ISA. However, because amphibians are more common, more sensitive, and there is toxicity data for them (or other more protective aquatic species), we propose to assess amphibians (or other aquatic species) as a surrogate for reptiles. Thus, protection of reptilian species will be ensured through protection of more sensitive aquatic species.

In conclusion, the results of this reconnaissance survey indicate that aquatic plants and amphibians are present in the ISA and could have potentially complete exposure pathways. The potential exposure is most likely greater in the quiescent areas (Figure 3) where more sensitive life stages are likely to be found. These areas will be the focus of any qualitative evaluations or data collection needed for a quantitative risk assessment.

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Subattachment B2A: Photographs[2]

Photograph: Site 2.jpg

2. Selected photographs cited in the text are included in this subattachment, which is published as a separate document; the full folio of 30 site photographs is available from Windward on request.

Photograph: Site 2-Red-legged frog-a.jpg

Photograph: Site 3.jpg

Photograph: Site 4.jpg

Photograph: Site 10a.jpg

Photograph: Site 10b.jpg

Attachment B3: Lamprey Ammocoete and Benthic Infaunal Biomass Reconnaissance Surveys of the Lower Willamette River

September 16-17, 2002
and
October 8-9, 2002

REVISED DRAFT FINAL
October 27, 2003

Prepared for:
Lower Willamette Group

Prepared by:
Striplin Environmental Associates, Inc. (Olympia, WA)
and
Windward Environmental, LLC (Seattle, WA)

LWG Survey – September 16-17, 2002

Introduction

On 16 and 17 September 2002, a field team consisting of Striplin Environmental Associates (SEA), Windward Environmental, Ellis Ecological, and Fishman Environmental personnel visited 21 of the 22 co-located sediment and tissue sampling stations, originally identified in the June 2002 LWG Field Sampling Plan (SEA 2002) and as modified during the subsequent fishing efforts. The main objective of this reconnaissance survey was to determine whether juvenile lamprey (ammocoetes) could be collected using backpack electroshockers or surface grab samplers in adequate numbers to allow for tissue chemical analyses. Also, because lamprey collection techniques included sediment grab sampling, an ancillary objective was to assess the apparent biomass and composition of the soft-bottom, benthic infaunal community to determine whether adequate biomass of infauna were present to allow for tissue chemical analysis.

Ammocoetes are the larval form of fish from the family Petromyzontidae (lampreys). Four species of lamprey are native to the Willamette River. The Pacific lamprey, and the river lamprey, are anadromous species. Whereas, the western brook lamprey, and the Pacific brook lamprey are resident species. Lamprey ammocoetes in the Willamette River remain burrowed in the freshwater sediment until maturity (up to 7 years) filter-feeding on phytoplankton and detritus (Kostow 2002; Moore and Mallat 1980). Lamprey are poor swimmers and anadromous forms are believed to outmigrate during spring flooding (Jackson et al. 1997).

Methods

Sampling was conducted on-foot (backpack electrofishing) and from a 20’ boat equipped with a davit and electronic capstan for sediment grab deployment and retrieval. As warranted based on each station’s physical setting, shoreline habitats, and accessibility, beach electroshocking for lamprey ammocoetes and beach and subtidal sediment sampling (hand-held spoons, Ekman and van Veen grab samplers) for lamprey ammocoetes, soft-bottom benthos, and bivalves were conducted. Sediments were sieved through both 1.0 mm and 0.5 mm screens at a subset of stations and representative benthic infauna specimens were retained for latter examination in the laboratory, although no attempt was made to quantitatively sample the benthos. Infaunal organisms were identified to major taxonomic categories following the survey and bivalves were identified to the genus level.

Results

Table 1 lists the stations visited during this reconnaissance in chronological order and the major site-specific observations. Table 1 also provides a summary of the benthic infauna data, and conclusions on whether adequate benthic biomass might be collected at a given location to allow for chemical analyses of composite invertebrate tissue samples. Table 2 provides details on the lamprey ammocoetes electrofishing efforts and results at each station. Figure 1 shows the locations where collection of benthos and lamprey ammocoetes was attempted.

Conclusions and Recommendations

Lamprey

The backpack electroshocking was only successful at collecting lamprey ammocoetes at one (04R004) of the sixteen stations sampled. Two lamprey ammocoetes were collected at this site and one specimen was released and subsequently re-found with the electroshocker. This suggests that the electroshocking approach is successful at finding lamprey ammocoetes when they are present. Electroshocking was not attempted at several stations without apparent suitable habitat, i.e., steep-sloped rip-rapped shorelines.

Other methods evaluated for catching lamprey ammocoetes included grab sampling and hand-scooping of beach sediments in areas that appeared to be suitable habitat. Beach and/or subtidal sediments were collected and sieved at 15 of the target stations. No lamprey ammocoetes were collected in the sediment grab samples. A small epibenthic dredge was mobilized for this reconnaissance but nearshore sediment dredging was not attempted at any station because of the shallow-water levels, uneven bottom terrain, and nearshore structures (dolphins, piers, etc.). Given the apparent low abundance of lamprey ammocoetes in the area surveyed in mid-September, the probability of collecting lamprey ammocoetes in a sediment grab sample seems quite low.

Overall, because numerous, apparently high quality habitat locations were sampled with both standard electrobackpacking and sediment sampling equipment without finding lamprey, it is doubtful that other methods would yield sufficient quantities of lamprey at this time of the year to allow tissues analyses. It is possible that sampling in other seasons, e.g., spring, would yield different results.

Benthos

Sediments were collected and sieved at 15 of the target co-located stations. Soft-bottom benthos observed consisted of oligochaetes, bivalves, chironomids, and amphipods. Oligochaetes and chironomids were present in low abundances in most fine-grained (silts) areas. Amphipods were observed only at downriver locations

(RM 2-3). The bivalve, *Corbicula*, was widespread in areas with an obvious sand fraction. With the exception of these bivalves at certain locations where there were individual clams equal to or greater than about 3 cm in length, the tissue biomass of the soft-bottom infaunal assemblage appeared to be extremely low as a result of both relatively low abundances and the small size of individuals (e.g., most specimens passed through the 1.0-mm screen but were retained on the 0.5-mm screen). As an example, the sieving of one-half of the 0.1-m^2 van Veen grab sample at 08R002 (about a one hour effort by three field staff) produced a total of 20 oligochaetes, up to about 3 cm in length, and 9 chironomids. The entire biomass of this sample was too low to be accurately weighed, but it was certainly no more than a fraction of a gram. In studies in Lake Erie, Soster et al. (2001) report that oligochaetes (tubificids) less than 3 cm in length average less than 1 mg each (dry weight).

Based on this reconnaissance effort, the only soft-bottom benthic organism that could potentially provide sufficient biomass for laboratory tissue analyses is the exotic bivalve, *Corbicula*. At several locations (02R001, 03R001, 05R001, 06R002, 07R003), *Corbicula* may be abundant and large enough to provide sufficient biomass for tissue chemical analyses with a reasonable effort (e.g., 1-2 days per site). In addition, large specimens of the mussel, *Margaritifera*, were collected at Station 05R002, but their origin at this location is uncertain because it is just off a public boat ramp and these specimens may have been transported and disposed there from elsewhere on the river.

Umatilla Tribal Biologists Lamprey Survey – October 8-9, 2002

Introduction

On 8 and 9 October 2002, a field team consisting of two lamprey biologists from the Umatilla tribe, Aaron Jackson and Brandon Trelor, as well as Striplin Environmental Associates (SEA), Windward Environmental, Ellis Ecological, Fishman Environmental personnel, and Hellen Hilman of NOAA visited 11 Lower Willamette sites. The objective of this reconnaissance survey was to assess whether juvenile lamprey (ammocoetes) could be found in the Lower Willamette using techniques/backpack electroshocking equipment specifically designed for that purpose.

Methods

Sampling was conducted either on-foot (backpack electrofishing) or from a small outboard aluminum boat. Sites were selected based on previous collection of lamprey ammocoetes and presence of fine sediments in the shallow intertidal zone. An ABP-2 electroshocker specifically designed by the University of Wisconsin for collecting lamprey ammocoetes was used. Each site was shocked until the Umatilla Biologists were satisfied that no lamprey were present. A setting of 125 volts with 3 pulses per second and a 25% duty cycle is normally used to withdraw larvae from the substrate. Once larvae emerge from the substrate, a setting of 30 pulses per second was to be applied to stun and capture. However, because lamprey were not present, capture methods were not employed.

Habitat quality at each site was qualitatively assessed based on substrate characteristics as either Type 1, Type 2, or unsuitable:

Type 1 - Preferred ammocoete habitat where ammocoetes can easily burrow. Consists of fine sediments with some organic matter. Some cover, such as detritus or aquatic vegetation, is optimal.

Type 2 – Acceptable, but not preferred ammocoete habitat. Substrate that is soft enough for larvae to burrow but with little fine organic matter and some gravel present.

Unsuitable – Habitat that larvae cannot burrow into.

Results

Table 3 provides details on the lamprey ammocoete electrofishing efforts and results at each station. Figure 1 shows the locations where lamprey ammocoete collection was attempted.

Conclusions and Recommendations

The backpack electroshocking was not successful at collecting lamprey ammocoetes at any of the 11 stations sampled. Aaron Jackson suggested that additional sampling in June or July may yield better results.

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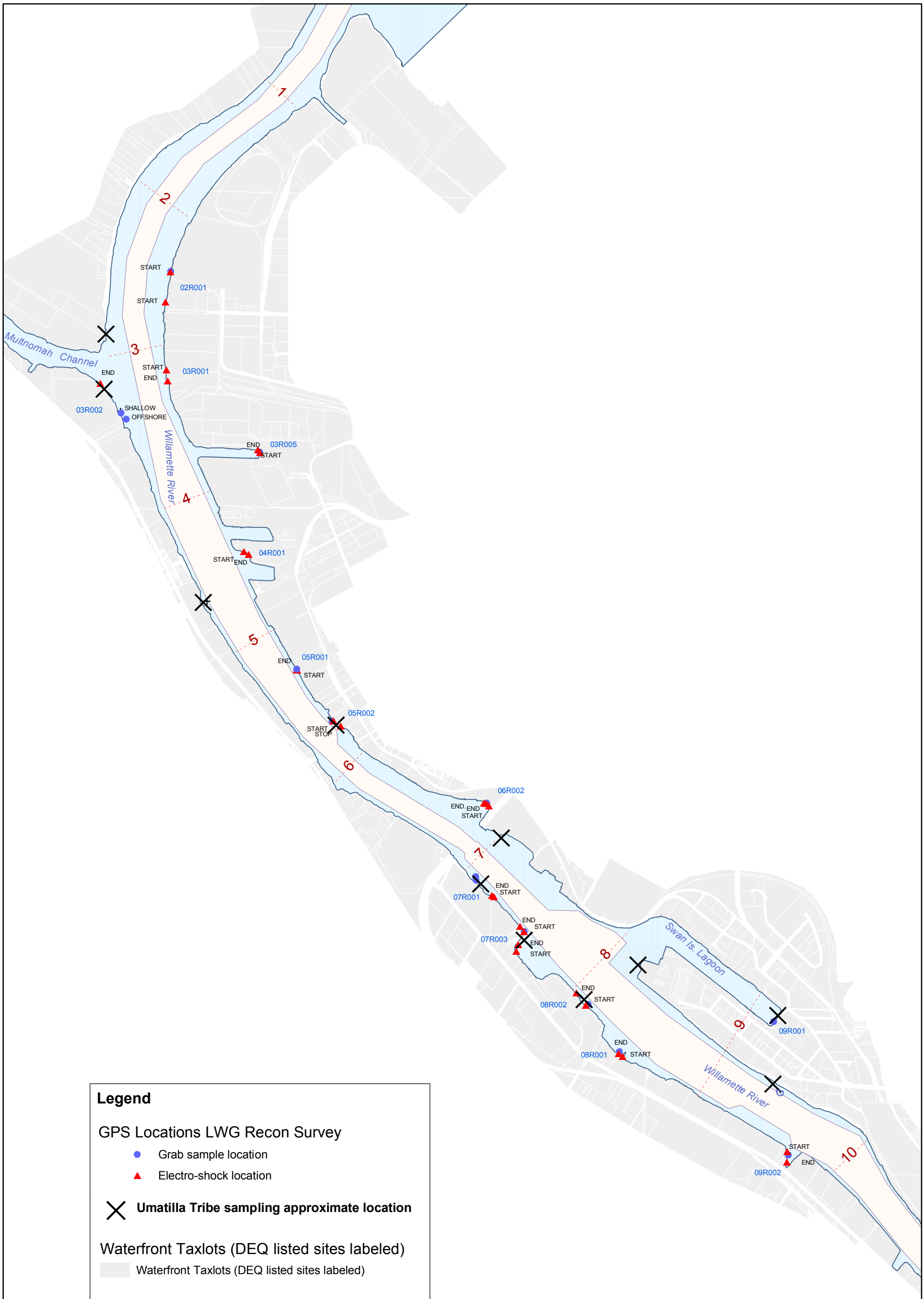
1
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START
02R001
START
Multnomah Channel
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START
END
03R001
03R002
SHALLOW
OFFSHORE
Willamette River
END
03R005
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04R001
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END
05R001
START
05R002
START
STOP
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END
06R002
START
END
START
07R001
END
START
07R003
END
START
END
START
08R002
Swan Is. Lagoon
END
08R001
START
09R001
Willamette River
START
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09R002
Legend
GPS Locations LWG Recon Survey
Grab sample location
Electro-shock location
Umatilla Tribe sampling approximate location
Waterfront Taxlots (DEQ listed sites labeled)
Waterfront Taxlots (DEQ listed sites labeled)
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LWG
LOWER WILLAMETTE GROUP
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1,500
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Benthic/Lamprey Recon
Sampling Locations
Sept. & Oct 2002
Figure 1

Table 1. Stations Visited during the Lamprey and Benthic Reconnaissance and Benthic Observations.

Station	Location	Date	Time	Electro-shocking	Grabs	Organisms (# observed)	Site Observations	Comments
09R001	Head of Swan Island Lagoon	9/16/2002	0920-1000	No lamprey	No			
07R002	Northwest Corner of McCormick & Baxter	9/16/2002	1015-1115	No lamprey	No, hand scooped some surface sediment and sieved at 1.0 mm, small clams - *Corbicula*		Lots of Sheens when surface sediment disturbed, sandy sediments	May be get clams here for tissue analyses, Health & Safety caution
04R004	gently sloping beach off Linnton	9/16/2002	1130-1300	Two Lamprey, one captured and released and shocked up again	Yes, van Veen just offshore (8-10' depth), sieved at 0.5 mm, sample saved	*Corbicula* (1) Oligochaetes(14) Chironomids(1)	Very soft, unconsolidated silt/clay, subtle, thin brown surface layer, uniform to bottom of grab (~20 cm)	Could not get soft-bottom tissue biomass here, could try higher on beach for clams
02R001	off OSM	9/16/2002	1330-1440	No lamprey	Yes, took 6 Ekman grabs in 3-4' depth just off beach, small amphipods (corophium?), bivalves. Took 2 grabs further off beach, sandy silt and silts, small oligochaetes only, samples combined and saved	*Corbicula* (7) Oligochaetes(4) Corophium(4)	Relatively steep sloped sandy beach, transistionals to sandy silts just offshore)	May be able to get clams here with effort
03R002	mouth of Multnomah Channel	9/16/2002	1448-1545	No lamprey	yes, collected 3 Ekman grabs on clay (4'), just offshore in silt (16'), and near beach (1-2'), combined contents of all grabs and sieved at 0.5 mm)	*Corbicula* (2) Oligochaetes(4) Corophium(3)	Substrate at beach hard clay, gently sloping	Clams present but very small
03R001	east bank at RM 2.2	9/16/2002	1600-1620	No lamprey	3 Ekman grabs, sieved, 1 small clam (not retained)	*Corbicula*	Relatively steep sloped beach with well-sands	Clams present but small
03R003		9/16/2002	by passed	Not sampled	Not sampled		Appeared similar to 03R001, well-sorted sandy beach	

Table 1. Stations Visited during the Lamprey and Benthic Reconnaissance and Benthic Observations.

Station	Location	Date	Time	Electro-shocking	Grabs	Organisms (# observed)	Site Observations	Comments
03R004		9/16/2002	by passed	Not sampled	Not sampled		Appeared similar to 03R001, well-sorted sandy beach	
04R003	small beach at head of T-4	9/16/2002	can't access by boat due to pilings	Not sampled	Not sampled			
04R001		9/16/2002	1648-1706	No lamprey	Not sampled		Hard-packed, well-sorted sandy beach	
04R002		9/16/2002	can't access station by boat due to pilings					
05R001		9/16/2002	1718-1730	No lamprey	3 Ekman grabs, sieved, 1 small clam (not retained)	*Corbicula* (small)	Well-sorted sandy small beach with some gravel, surrounded by riprap	May be able to get clam biomass here with effort
09R002	T-2 Notch	9/17/2002	0750-0820	No lamprey	2 Ekman grabs, sieved 1.0 mm and 0.5 mm, also sampled shallow areas/beach with spoon (sieved at 10, mm)	*Corbicula* (1) oligochaetes	Fine-grained sediments with some stiffness at depth, subsurface wood debris, sand layers	Insufficient benthos biomass for laboratory analyses

Table 1. Stations Visited during the Lamprey and Benthic Reconnaissance and Benthic Observations.

Station	Location	Date	Time	Electro-shocking	Grabs	Organisms (# observed)	Site Observations	Comments
08R001	off Shaver	9/17/2002	0830-0900	No lamprey	1 van Veen, unconsolidated silt-clay, stiffer at depth, sieved 1/2 grab to 10-15 cm through 0.5 mm sieve,	few animals detected in top of sample not retained, Oligochaetes Chironomids, below 10-15 cm larger oligochaetes	Relatively steeped sloped beach with gravels and cobbles, grabs collected off beach in 5-6' near pier	Insufficient benthos biomass for tissue analyses
08R002	off McCall Oil, station moved downstream	9/17/2002	0930-1025	No lamprey	1 Ekman, 1 van Veen in 5' depth sieved, 1/2 grab through 0.5 mm sieve	Oligochaetes(20) Chironomids(9)	Rocky beach transitions to unconsolidated silt-clay just offshore	Insufficient benthos biomass for tissue analyses
07R003	downstream side of Willbridge Terminal	9/17/2002	1035-1120	No lamprey	15+ large spoonfuls (to 15 cm) taken from 0-1' depth and sieved through 0.5 mm screen. Corbicula clam beds	*Corbicula* (2)	Gently sloping mud/sandflat with sand ripples	May be able to get clam biomass here for tissue analyses
07R001	off ATOFINA	9/17/2002	1150-1300	No lamprey	1 van Veen taken off beach in 8' water, 1/2 grab sieved to 10 cm depth	*Corbicula* (1) Oligochaetes(14) Chironomids(1)	Gently sloping fine-grained beach, just off beach bottom is unconsolidated silt-clay with no obvious stratification	Insufficient benthos biomass for laboratory analyses
06R002	Willamette Cove	9/17/2002	1305-1325	No lamprey	5 Ekman grabs (0-5cm) sieved through 0.5mm screen, sandy with some fines (not retained)	*Corbicula* Oligochaetes Chironomids	Sandy, relatively steep-sloped beach surrounded by riprap	May be able to get clams biomass here with effort

Table 1. Stations Visited during the Lamprey and Benthic Reconnaissance and Benthic Observations.

Station	Location	Date	Time	Electro-shocking	Grabs	Organisms (# observed)	Site Observations	Comments
06R001	U.S. Moorings	9/17/2002	1135-1345	No sampling	None		Gently sloping muddy beach surrounded by riprap, too shallow for beach access and substrate too soft to walk on, site not sampled	
05R002	Public boat ramp, just downstream of St. John's Bridge	9/17/2002	1355-1440	No lamprey	2 van Veens, sampled somewhat washed due to debris, wood, penetration < 10 cm	2 large mussels - *Margaritifera sp.*	1 Large mussel collected per grab but may have been disposed here near boat ramp	If mussels actually present, then biomass can be obtained
03R004 (revisit)		9/17/2002	1145-1500	Not sampled	None		No beach present at this water level, only riprap, so not sampled	
03R005	head of Schnitzer Waterway	9/17/2002	1510-1530	No lamprey	10 Ekman grab attempts, grab won't seal due to stick, cobbles, rocks in jaws, no sample obtained		Small, debris-covered beach at head of waterway	Unlikely to be sufficient benthos biomass for laboratory analyses
09R001	Head of Swan Island Lagoon	9/17/2002	1530-1600	Not sampled (sampled on 9/16)	2 van Veens in 6' depth, sandy substrate with rocks interspersed that prevented grab from closing	None obvious in washed grab samples		

Table 2. Lamprey Backpack Electroshocking Sampling Details and Results.

Date	Site	Setting	Voltage	Total Electrofishing Time (s)	Time	Lineal Distance (ft)	Notes	Results
9/16/2002	09R001	D4	100 to 600	not recorded	920-1000	not recorded	Ran through shocker settings starting at D4-100 volts through 1000 volts then A2-100 volts through 1000 volts, etc. through all of the A settings, then all of the B settings. All of the combinations of settings on the shocker were used for about 30 seconds per voltage. At higher hertz and higher cycles per second only lower voltages were usable before the system signaled overload.	No lamprey. A few worms were shocked.
9/16/2002	07R002	all	100 to 1000	not recorded	1015-1115	not recorded	Ran through shocker settings starting at D4-100 volts through 600 volts then A4-100 volts through 600 volts, then B4-100 volts through 600 volts etc. until all settings A through L were used. Each setting was shocked for about 30 seconds.	No lamprey.
9/16/2002	04R004	all	100 to 1000	not recorded	1130-1300	not recorded	Location of previous lamprey collection.	2 lamprey were observed. Only one was collected (2g, ~ 9cm.)

Table 2. Lamprey Backpack Electroshocking Sampling Details and Results.

Date	Site	Setting	Voltage	Total Electrofishing Time (s)	Time	Lineal Distance (ft)	Notes	Results
9/16/2002	02R001	D4	500	829	NR	1005	Began using only setting D4 because the lamprey collected at the previous site were collected on this setting at 500 volts.	No lamprey.
9/16/2002	03R002	D4	500	1011	1455-1535	1136	Effort divided among 4 stretches of beach. Voltage of 600 to 800 v for last two segments.	No lamprey.
9/16/2002	03R001	D4	600	400	1558-1609	352		No lamprey.
9/16/2002	04R001	D4	600	422	1648-1657	183	Sandy bottom, visibility to about 2 ft depth. some fine wood debris on sediment surface.	No lamprey.
9/16/2002	04R002					NA	No sandy beach, all riprap. didn't shock.	No lamprey.
9/16/2002	05R001	D4	600	280	1718-1723	35	~ 30m long sandy beach surrounded by rip rap.	No lamprey.

Table 2. Lamprey Backpack Electroshocking Sampling Details and Results.

Date	Site	Setting	Voltage	Total Electrofishing Time (s)	Time	Lineal Distance (ft)	Notes	Results
9/17/2002	09R003	D4	600	762	0754-0820	not recorded	Voltage range from 600 to 800 volts. Silt and clay substrate with some sand on beach. A few patches of fine woody detritus. Possibly shocked some organism (silt cloud) but couldn't ID it.	No lamprey.
9/17/2002	08R001	D4	600	383	0833-0920	164	Substrate sand to gravel.	No lamprey.
9/17/2002	08R002	D4	500	920	0927-0950	512	Substrate gravel mixed with sand, shocking divided 620 seconds upstream of spit, 300 seconds downstream of spit.	No lamprey.
9/17/2002	07R003	D4	500	892	1041-1057	221	Substrate clay/silt/fine sand. more cohesive at depth. Shocking divided between 520 seconds on north end and 372 seconds on south end of site.	No lamprey.
9/17/2002	07R001	D4	500	378	1151-1218	90	Could not sample site because substrate was too soft to walk on. sampled under ATOFINA dock, upstream of target.	No lamprey.

Table 2. Lamprey Backpack Electroshocking Sampling Details and Results.

Date	Site	Setting	Voltage	Total Electrofishing Time (s)	Time	Lineal Distance (ft)	Notes	Results
9/17/2002	06R002	D4	500	544	1305-1330	266	Substrate sand with some rip rap. shocked up 1 sculpin and 1 smallmouth bass.	No lamprey.
9/17/2002	06R001					NA	Did not shock because substrate too soft to walk on. Similar to ATOFINA site 07R001.	No lamprey.
9/17/2002	05R002	D4	500	680	1355-1415	300	Substrate small rocks and sand, some small wood debris on silty sand. Looks like good lamprey habitat. 1 smallmouth bass shocked up.	No lamprey.
9/17/2002	03R004					NA	No beach visible so didn't shock.	No lamprey.
9/17/2002	03R005	D4	500	296	1510-1520	107	Substrate sand with some small rocks.	No lamprey.
9/17/2002	05R002	Public boat ramp, just downstream of St. John's Bridge	1355-1440	No lamprey	2 van Veens, sampled somewhat washed due to debris, wood, penetration < 10 cm	2 large mussels - *Margaritifera sp.*	1 Large mussel collected per grab but may have been disposed here near boat ramp	If mussels actually present, then biomass can be obtained

Table 2. Lamprey Backpack Electroshocking Sampling Details and Results.

Date	Site	Setting	Voltage	Total Electrofishing Time (s)	Time	Lineal Distance (ft)	Notes	Results
9/17/2002	03R004 (revisit)		1145-1500	Not sampled	None		No beach present at this water level, only riprap, so not sampled	
9/17/2002	03R005	Head of Schnitzer Waterway	1510-1530	No lamprey	10 Ekman grab attempts, grab won't seal due to stick, cobbles, rocks in jaws, no sample obtained		Small, debris-covered beach at head of waterway	Unlikely to be sufficient benthos biomass for laboratory analyses
9/17/2002	09R001	Head of Swan Island Lagoon	1530-1600	Not sampled (sampled on 9/16)	2 van Veens in 6' depth, sandy substrate with rocks interspersed that prevented grab from closing	None obvious in washed grab samples		

Table 3. Umatilla Lamprey Biologists Electrofishing Results.

Date	Site	Total Electrofishing Time (s)	Time	Habitat Type	Notes
10/8/2002	Atofina beach, station 07R003	NR	1200	Type 1 to Type 2	No lamprey collected, shocked along the bay area
10/8/2002	McCormack and Baxter	1851	1335	Type 1	2 sculpin sited. No lamprey collected. Habitat was fines with detritus and organics
10/8/2002	St Johns Boat Ramp	1713	1500	Type 1 to Type 2	No lamprey or other organisms collected
10/8/2002	04R004	1589	1540	NR	1 sculpin sited but not caught, no lamprey collected
10/8/2002	07R001	834	1706	Type 1 to Type 2	No lamprey or other organisms collected
10/9/2002	Coast Guard facility	800	1030	NR	No lamprey or other organisms collected
10/9/2002	08R002	800	1100	Type 2	No lamprey or other organisms collected
10/9/2002	09B026	685	1135	NR	No lamprey or other organisms collected
10/9/2002	09R001	500	1155	Type 2	No lamprey or other organisms collected
10/9/2002	Beach near Multnomah channel	700	1340	Type 2	No lamprey or other organisms collected
10/9/2002	02R013	600	1345	NR	Beach has film of algae and detritus covering sand. No lamprey or other organisms collected

Attachment B4: Proposed Process for Assessment of Benthic Risks at the Portland Harbor Superfund Site

NOTE:

The proposed process for the benthic approach has been removed. A revised memorandum will be submitted to EPA as part of the technical memorandum process.

Attachment B5: Ecotoxicological Profiles

1.0 INTRODUCTION

The historical dataset for the ISA was evaluated in order to identify the classes of compounds that have been previously measured in the sediment, tissues, and surface water collected within the ISA and to ensure that the analytical methods selected for the Round 1 samples were appropriate and inclusive of the wide range of analytes previously measured in ISA samples. The selected target analytes represented the following chemical classes: metals, organometals, PAHs, PCBs, dioxins and furans, pesticides, herbicides, and volatile organic compounds. Brief summaries of the types of impacts reported in the literature for each COPC group (e.g., metals) on benthic invertebrates, fish, and wildlife will be provided below.

2.0 METALS

2.1 Benthic organisms

Toxicity of metals to benthic organisms ranges widely, from a slight reduction in growth rate to mortality. Oligochaetes and mollusks are generally less sensitive to metals than other aquatic phyla (Leland and Kuwabara 1985). The most sensitive life stages of benthic organisms are the embryonic and larval stages. The speciation and bioavailability of metals determine their relative toxicity. TBT has been observed to cause imposex in snails and suppression of regeneration in echinoderms (Eisler 1989; Gibbs et al. 1990). Mercury adversely affects reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange in benthic organisms (Eisler 1987b).

2.2 Fish

Fish are exposed to metals through their gills and through ingestion pathways. The larval stages are generally most sensitive. Transition metals, such as cadmium, lead, copper, and zinc, are more toxic in their free divalent state than in particulate or complexed forms (Wong et al. 1978). Commonly observed effects of transition metals and metalloids include reductions in growth, survival, and fecundity (Jarvinen and Ankley 1999). Biochemical and histopathological effects have also been reported (e.g., James and Wigham 1986). Mercury can adversely affect fish reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange. Responses to chronic exposure to mercury include emaciation, brain lesions, cataracts, diminished responses to change in light intensity, inability to capture food, abnormal motor coordination, erratic behavior, and death (Armstrong 1979; Hawryshyn et al. 1982; both as cited in Eisler 1987b). Sublethal effects of copper exposure to fish include reduced growth and behavioral changes, such as the disruption of migratory patterns of salmonids. Tributyltin inhibits mitochondrial and

oxidative phosphorylation in fish, causing sluggishness, loss of appetite, altered body pigmentation, air gulping, loss of positive rheotaxis, increased rate of opercular movements, damaged gills, cornea, and epithelial cells of the bile duct, and increases in blood hemoglobin, erythrocyte numbers, and hematocrit (Chliamovitch and Kuhn 1977; Thompson et al. 1985, both as cited in Eisler 1989).

2.3 Wildlife

Birds—Avian dietary toxicity studies have been conducted with a wide range of metals. The observed toxicity of the metals depends on the level of metallothioneins in the bird. Sublethal effects can include reproductive and behavioral modifications. Teratogenic effects have been documented in chicken embryos after eggs were injected with chromium (Ridgeway and Karnofsky 1952; Gilani and Marano 1979, as cited in Eisler 1986). Methylmercury is more toxic to birds than inorganic mercury, and young birds are more sensitive than older birds (Eisler 1987b). Sublethal mercury poisoning can cause adverse effects on growth, development and reproduction, blood and tissue chemistry, metabolism, and behavior. Muscular incoordination, falling, slowness, fluffed feathers, calmness, withdrawal, hyporeactivity, hypoactivity, and drooping eyelids have been observed in birds exposed to mercury (Eisler 1987b). Numerous effects have on observed in birds exposed to lead, including damage to the nervous system, muscular paralysis, kidney and liver damage, internal lesions, enlarged gall bladder, anemia, reduced brain weight, abnormal skeletal development, and mortality (Eisler 1988). Very little information is available on the effects of tin and organotins on birds. Triorganotins are considered to be the most toxic. Possible effects of triorganotin poisoning include tremors, ataxia and lethargy, and degeneration and necrosis of the large neurons of the pons, medulla oblongata, gray matter of the spinal cord, and cells of the cerebral cortex (Eisler 1989).

Mammals— Methylmercury and lead can biomagnify within food chains and expose higher trophic level mammals in aquatic systems. Organomercury compounds, especially methylmercury, are the most toxic mercury species for mammals. Mercury causes teratogenic, mutagenic, and carcinogenic effects in mammals. The kidney is the primary organ affected by mercury poisoning in adult mammals and the brain is the primary target organ in fetuses (Suzuki 1979; Khera 1979, both as cited in Eisler 1987b). At low concentrations, mercury can affect reproduction, growth and development, behavior, blood and serum chemistry, motor coordination, vision, hearing, histology, and metabolism (Eisler 1987b). Larger mammals such as seals appear to be more resistant to mercury than smaller mammals such as mink and river otters (Eisler 1987a). The reasons for these differences in sensitivity are unknown, but may be related to differences in metabolism and detoxification. Lead modifies the function of and structure of kidney, bone, the central nervous system, and the hematopoietic system, and produces adverse biochemical, histopathological, neuropsychological, fetotoxic, teratogenic, and reproductive effects (Eisler 1988). Food-chain biomagnification of lead may be important for carnivorous marine mammals, such as the California sea lion and harbor seal (Eisler 1980). Tributyltin is

highly toxic to mammals. It causes chromosomal aberrations and reduction in thymus weight (Snoeij et al. 1985; Dixon and Prosser 1986, both as cited in Eisler 1989).

3.0 PESTICIDES

3.1 Benthic organisms

The mechanisms by which organochlorine pesticides cause toxicity include narcosis (nonspecific toxicity) and more specific mechanisms that result in enhanced toxicity, such as respiratory uncouplers, acetylcholine esterase (AChE) inhibitors, and central nervous system convulsants (Lipnick 1993; McCarty and Mackay 1993).

Relatively little information is available relating sediment-associated pesticides with toxicity to benthic organisms, although some studies with DDT have been conducted (Nebeker 1988). Most sediment guidelines for pesticides have been developed from samples that contain a myriad of other contaminants, any of which may have contributed to the adverse effects associated with those samples.

3.2 Fish

Exposure of fish to organochlorine pesticides can result in narcosis (nonspecific toxicity) and more specific toxicity, such as respiratory uncouplers, acetylcholine esterase (AChE) inhibitors, and central nervous system convulsants (Lipnick 1993; McCarty and Mackay 1993). Additionally, the DDT metabolites DDD and DDE have been shown to be acutely toxic to a number of fish species. In addition to its toxic effects, DDT bioaccumulates significantly in fish and other aquatic species, leading to long-term exposure. A half-life for elimination of DDT from rainbow trout was estimated to be 160 days (EXTOXNET 1996).

Recent research suggests that organophosphate and carbamate insecticides may harm fish by blocking synaptic transmission by inhibiting neuronal acetylcholinesterase (Ferenczy et al. 1997; Sturm et al. 1999), which may have adverse effects on fish behavior such as predator avoidance and homing behavior. A study by Scholz et al. (2000) reported that the organophosphate pesticide diazinon inhibited olfactory-mediated alarm responses in chinook salmon.

The Washington State Pesticide/ESA Task Force is currently undertaking a systematic evaluation to identify pesticides that may cause harm or are potentially limiting to recovery of ESA-listed salmonids. This process will evaluate the potential of pesticides to cause direct harm to salmonids, harm through impairment of behavioral patterns, and harm through reduction of prey. Pathways to be considered include surface water, diet, sediment, and groundwater intrusion. The evaluation is just beginning at this time so the results were not available for incorporation into this

risk assessment. Thus far, research involving pesticides and salmon has focused on water column issues.

3.3 Wildlife

Birds—Birds are generally less sensitive to dieldrin than aquatic organisms, although they can have increased exposure because they are higher in the food chain and dieldrin can biomagnify. Gamma-BHC is slightly to moderately toxic to birds; eggshell thinning and reduced egg production have occurred in birds exposed to gamma-BHC (EXTOXNET 1996).

There has been much concern over chronic exposure of bird species to DDT and effects on reproduction, especially eggshell thinning and embryo mortality. The mechanism associated with eggshell thinning is not fully understood, although it is believed predatory birds may be more sensitive to these effects. Extensive field data have associated DDE concentrations in egg to reduced productivity in wild breeding birds, aquatic birds, and raptors (Blus 1995). Laboratory studies on avian reproduction have demonstrated the potential for DDT and DDE to cause subtle changes in courtship behavior, delays in pairing and egg laying, and decreases in egg weight in ring doves and Bengalese finches (EXTOXNET 1996). In addition, numerous toxicity studies have demonstrated the potential for DDE to induce eggshell thinning and/or egg desiccation in avian species.

Mammals—Some organochlorine pesticides such as o,p′-DDT, kepone, and methoxychlor have estrogenic activity in wildlife. Many of these compounds, including o,p′-DDT and kepone, have been shown to act by binding to the estrogen receptor. However, other organochlorine compounds can exert estrogenic or anti-estrogenic effects by other mechanisms (Carey et al. 1998). The overall impact of such estrogenic activity is typically disruption of normal reproductive functioning.

In addition, several chlorinated pesticides are known to affect mammalian immune system function. These pesticides include hexachlorobenzene, mirex, lindane, chlordane, dieldrin, and DDT and its metabolites (Carey 1994). The immunotoxic effects of these compounds have been demonstrated in several species and include loss of resistance to infections. In most cases, the mechanism of action for these compounds is not well known.

4.0 PAHS

4.1 Benthic organisms

Effects of PAHs on benthic invertebrates include inhibited reproduction, delayed emergence, sediment avoidance, and mortality (Eisler 1987a; Landrum et al. 1991). In a study of PAH toxicity to the amphipod *Diporeia*, the mechanism identified as

most likely responsible for observed acute toxic responses to PAHs was narcosis (Landrum et al. 1991). Generally, aquatic invertebrates are less able to metabolize PAHs than aquatic vertebrates, although rates of PAH metabolism vary widely within and between phyla (Meador et al. 1995). Thus, invertebrates tend to be more sensitive to PAHs due to acute lethality by narcosis than other organisms that actively metabolize these compounds.

4.2 Fish

In most fish, PAHs are rapidly metabolized and excreted following uptake, so PAH tissue concentrations are generally low. The major route of elimination is through excretion into bile. Biotransformation and excretion rates can vary widely among fish species (Meador et al. 1995). Fish exposed to PAHs may be induced to produce higher levels of enzymes capable of transforming PAHs to more excretable, but occasionally more carcinogenic, metabolites (O'Connor and Huggett 1988).

Low-molecular-weight polycyclic aromatic hydrocarbons (LPAHs) such as naphthalene, fluorene, phenanthrene, and anthracene are acutely toxic to fish and other aquatic organisms. Acute lethality increases with increasing alkyl substitution on the lower molecular weight compounds (Van Luik 1984). Many of the high-molecular-weight polycyclic aromatic hydrocarbons (HPAHs), such as chrysene and benzo(a)pyrene, are less acutely lethal but demonstrably carcinogenic, mutagenic, or teratogenic to a wide variety of organisms including fish (Moore and Ramamoorthy 1984; Eisler 1987a). Elevated exposure of PAHs has been reported to result in reproductive impairment, immune dysfunction, increased incidence of liver lesions, and other histopathological endpoints (Malins et al. 1987; Johnson et al. 1988; Varanasi et al. 1992; Baumann et al. 1996). Fin erosion and liver abnormalities have also been observed in fish exposed to extracts from PAH-contaminated sediments (Fabacher et al. 1991). Other studies report sublethal effects on the cellular immune system (reduced macrophage activities) in fish exposed to PAH-contaminated sediments, that could result in increased susceptibility to disease (Weeks and Warinner 1984, 1986; Weeks et al. 1986). The most common diseases generally affect the liver, although cataracts and pollution-related disorders of the skin and gills may also occur (O'Connor and Huggett 1988).

4.3 Wildlife

Birds—Very few data are available on the toxicity of PAHs in birds. In one study, Patton and Dieter (1980) fed mallards diets containing 4,000 mg PAHs/kg for a period of 7 months. No mortality or visible signs of toxicity were evident during the exposure; however, liver weight increased 25%, and blood flow to the liver increased 30% when compared to controls (Eisler 1985). In addition, PAH mixtures applied to the surface of mallard eggs have been shown to result in increased embryo mortality and increased embryo deformation (Hoffman and Gay 1981).

Mammals—In mammals, several PAHs have been shown to be potent carcinogens. In general, PAH carcinogens transform cells through genetic injury involving metabolism of the parent compound to a reactive diol epoxide (Eisler 1985). In the case of benzo(a)pyrene, one isomer of the 7,8-diol, 9,10-epoxide is an exceptionally potent carcinogen to newborn mice and is believed to be the ultimate carcinogenic metabolite of this PAH (Slaga et al. 1978). One of the most toxicologically significant processes involved in response to PAH exposure is the interaction with drug-metabolizing enzyme systems. Increased production of mixed-function oxidase enzymes in various small mammals has been induced by numerous PAH compounds (EPA 1980b). Interspecies differences in sensitivity to PAH-induced carcinogenesis are due largely to differences in levels of mixed-function oxidase activities that affect rates at which active metabolites are converted to less active products (Neff 1979).

5.0 PCBS

5.1 Benthic organisms

There are significant interspecies differences in sensitivities to PCBs, even among species that are closely related taxonomically (Eisler 1986). Most studies of the effects of PCBs on benthic invertebrates have shown reproductive impairment and effects on survival and growth (Eisler 1986).

5.2 Fish

There are a number of effects observed in fish species due to exposure to PCBs (Eisler 1986). They include mortality (EPA 1980a), growth reduction (e.g., Mauk et al. 1978), reduced hatching success (e.g., Freeman and Idler 1975), and reduced fertilization success (e.g., Nebeker et al. 1974). Carcinogenic and biochemical perturbations have also been observed in several fish species (EPA 1980a).

The lethal toxicity of PCBs to fish varies with several factors which include the PCB formulation, the organism species and stage of development, and the test conditions employed (e.g., length of exposure, static versus flow-through tests, etc.) (Nagpal 1992). Aroclors containing 42 to 54% chlorine appear to be the most toxic formulations of PCBs in fish (Johnson and Finley, 1980; Mayer et al. 1977). In addition, injection of dioxin-like PCB congeners into fish eggs can cause early-life-stage mortality associated with blue-sac disease, which involves subcutaneous yolk sac edema (Wisk and Cooper 1990; Walker et al. 1991).

5.3 Wildlife

Birds— Chronic dietary exposure of various bird species to PCBs has been reported to result in a variety of reproductive effects, including reduced hatching success,

fledging rate, and egg production; embryo mortality; developmental deformities; and altered parenting behavior (Giesy et al. 1994; Hoffman et al. 1996). In addition, there appears to be significant inter-species variability in avian sensitivity to PCBs.

The most sensitive avian species tested in the laboratory appears to be domestic chickens, based on work done by Scott et al. (1971), Britton and Huston (1972, 1973), Lillie et al. (1974, 1975), and Ax and Hansen (1975). The other avian species for which extensive laboratory testing has been published is the mallard duck (Heath et al. 1972; Custer and Heinz 1980), which appears to be less sensitive than the domestic chicken. Controlled dietary exposures to PCBs have been conducted for a few other bird species (e.g., bobwhite quail, screech owls, pheasants), though few studies have described complete exposure-response relationships, most consisting of a single dietary dose.

A substantial effort has been expended investigating potential adverse reproductive and developmental effects in wild, piscivorous bird populations exposed to PCBs (Tillitt et al. 1992; Jones et al. 1993, 1994; Giesy et al. 1994a,b). Much of this research has focused on Great Lakes populations of double-crested cormorants, because reduced reproductive success and deformities in this species were found to coincide with high exposure to organic pollutants, including PCBs. In addition to embryo mortality, PCBs have been suggested by some researchers to cause edema and beak malformations, such as crossed beaks, in double-crested cormorants (Firestone 1973; Schrankel et al. 1982; Brunström and Darnerud 1983, all as cited in Brunström 1990). Injection of PCBs in raptor eggs has resulted in reduced egg production, eggshell thinning, reduced hatching success, and reduced fledging success (Fernie et al. 2001; McLane and Hughes 1980), suggesting the sensitivity of developing embryos to PCB exposure.

Mammals— Chronic exposure to PCBs has been shown to cause mortality or serious reproductive complications in mammals. Other effects associated with PCB toxicity include anorexia, liver and kidney degeneration, and gastric ulcers (Wren et al. 1991). Impacts to the immune system of marine mammals have also been suggested based on biomarker research (Van Loveren et al. 2000), although the biological significance of the observed biochemical changes is unknown. Like birds, mammals appear to vary widely in their sensitivity to dietary PCBs; reproduction appears to be the most sensitive population-level endpoint for PCB toxicity (Golub et al. 1991; Rice and O'Keefe 1995; Hoffman et al. 1996).

Controlled laboratory exposures of mink to PCBs have been extensively studied (Aulerich et al. 1985; Wren et al. 1987), and this species appears to be among the most sensitive mammalian species tested (Fuller and Hobson 1986) with reproductive impacts as the most sensitive endpoint. A review of the mink toxicity literature indicates that Aroclor 1254 is the most potent Aroclor tested in mink.

In addition, several studies have been conducted with mink that were fed field-collected fish contaminated with a number of organic pollutants, including PCBs,

dioxins, furans, and pesticides from Saginaw Bay (Restum et al. 1998). These studies have examined the multigenerational reproductive success of captive mink fed these field-collected fish.

6.0 DIOXINS AND FURANS

6.1 Benthic organisms

Aquatic invertebrates are generally less sensitive to the toxicity of polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) than fish. West et al. (1997) observed no effects in survival, growth, sexual, or asexual reproduction for two freshwater invertebrate species, the oligochaete (*Lumbriculus variegates*) and the midge (*Chironomus tentans*) orally exposed to TCDD. The maximum residue levels of the oligochaete (174 ng TCDD/g body wet weight) and the midge (144 ng TCDD/g body wet weight) suggested that these benthic organisms can accumulate high levels of PCDDs and PCDFs and remain relatively insensitive to the toxicity (West et al. 1997). Similarly, no effects on growth, reproduction, and food intake of snails and daphnids were observed while these organisms were immersed in solutions of 2.4-4.2 ng TCDD/L for 32 days (Yockim et al. 1978, as cited in Eisler 1986). This lack of sensitivity suggests that aquatic invertebrates may accumulate PCDDs and PCDFs from the sediment resulting in trophic transfer to the fish and wildlife that prey upon these organisms (West et al. 1997).

6.2 Fish

PCDD and PCDFs are toxic to fish. Exposure to low-levels of waterborne T_4CDD (38 pg TCDD/L) proved to be toxic to rainbow trout, resulting in decreased growth, behavior abnormalities including lethargic swimming, feeding inhibition, and lack of response to external stimuli, and mortality (Mehrle et al. 1988).

Several responses to exposure to PCDDs and PCDFs occur in fish: mortality, decreased survival, growth abnormalities, growth inhibition, immune response effects, blue-sac disease, loss of scale, and enzyme induction (Sijm and Opperhuizen 1996). Early life stages of fish are more sensitive to PCDD/PCDF exposure than adults (Eisler 1986; Sijm and Opperhuizen 1996). In a recent survey of studies, Sijm and Opperhuizen (1996) observed that lethal effects were observed at higher concentrations in experiments using adult fish than those with early life stages. Lake trout eggs and fry have been suggested to be the most sensitive to PCDD/PCDF toxicity and effects of toxicity in early life stages include reduced hatchability, the development of yolk sac edema and hemorrhages, and mortality (Peterson et al. 1993).

6.3 Wildlife

Birds—Chronic exposure to PCDDs and PCDFs has been shown to cause mortality and many sublethal effects including edema, impaired reproductive success, AHH induction, vitamin A depletion, beak deformities, and club foot in birds (Eisler 1986, Hoffman et al. 1996). Early life stages of birds have been shown to be more sensitive to PCDDs and PCDFs than adults and embryo mortality, decreased embryonic growth, and edema are perhaps the most common endpoints for birds (Hoffman et al. 1996). The effects of exposure vary by species and laboratory studies have indicated that chicken eggs may be the most sensitive to TCDD exposure in comparison to great blue heron, pheasant, and bluebird eggs (Hoffman et al. 1996). Laboratory studies involving egg injection of various bird species have resulted in adverse effects on hatchability and embryo mortality (Nosek et al. 1993; Janz and Bellward 1996; Powell et al. 1997).

Few studies have examined the effects of PCDDs and PCDFs on wild birds. White and Seginak (1994) investigated the reproductive effects on wood ducks in nest boxes downstream from a point source of PCDDs and PCDFs and reported that residues were higher in eggs close to the point source in comparison to eggs at a control site and overall reproductive success of the eggs close to the point source was diminished (as cited in Hoffman et al. 1996). Several field studies in the Columbia River estuary have considered elevated concentrations of dioxins in eggs to adverse effects on the reproductive success in bald eagles and cormorants (Buck 1999; Buck and Sproul 1999).

Mammals—PCDDs and PCDFs are toxic to mammals. The observed effects of exposure to PCDDs and PCDFs has been reported to range among laboratory mammals as primates develop chloracne-type skin lesions and rats, mice, and rabbits develop liver damage (Eisler 1986). Acute toxic responses to PCDDs reported to occur among laboratory mammals can include weight loss, hypophagia, muscular necrosis, and metabolic changes such as cachexia (Vanden Heuvel and Lucier 1993). Small mammals, such as the mink (Henny et al. 1996) and the guinea pig (Eisler 1986), are reported to be particularly sensitive to PCDDs and PCDFs. In addition, effects of exposure to TCDD have been reported to include diminished reproductive success in mammals including ovarian dysfunction, reduced fertility, prenatal mortality, and decreased litter size in rats (Peterson et al. 1993).

7.0 OTHER ORGANIC CHEMICALS

7.1 Benthic organisms

Very few data exist on the toxicology of volatile and semi-volatile organic chemicals to benthic organisms. In general, narcosis is the toxic endpoint associated with chemicals such as chlorobenzenes, phthalates, and chlorophenols (EPA 1995; Penttinen and Kukkomen 1998; Fuschman et al. 1999). Tagatz et al. (1986) as cited in

Staples et al. (1997) provides a study of potential impacts of dibutyl phthalate on benthic community structure. No impacts were observed at concentrations of 10 and 100 mg/kg in sediment, although 1,000 mg/kg dibutyl phthalate resulted in a significant reduction in benthic diversity.

7.2 Fish

Relatively fewer data exist on the toxicology of other semi-volatile organic compounds to fish. Water toxicity data for volatile organic compounds, such as chlorobenzene, are available, but tissue residue values are not. QSARs (quantitative structure-activity relationships) have been used (Roose and Brinkman 2000) to compare to concentrations of volatile organic compounds measured in fish collected from the North Sea. The toxic mechanism of chlorobenzene in fish is narcosis and the target site is in the cell membrane (Freidig and Hermens 2000).

The mode for toxic action by phenols is thought to be narcosis and/or the uncoupling of oxidative phosphorylation (Penttinen and Kukkonen 1998). Acute toxicity data are available for rainbow trout and fathead minnow (Babich and Stotzky 1985). No chronic toxicity data for phenol were available.

No data were found relating body burdens of phthalates to effects. Staples et al. (1997) provides an overview of toxicity studies conducted with fish and water exposures of various phthalates.

7.3 Wildlife

Birds—Few data are available regarding the ecotoxicology of volatile organic compounds and other compounds, such as phthalates, to birds. Hexachlorobenzene can be slightly to moderately toxic to birds. The organs affected by hexachlorobenzene exposure are the liver, kidneys, spleen, lungs, and nervous system (EXTOXNET). Phthalates have been suggested as a potential endocrine disruptor for wildlife, although no phthalate studies with birds were found.

Mammals—Data are available for assessing impacts of chemicals such as 2-methylphenol, butyl benzyl phthalate, benzidine, and hexachlorobenzene. These chemicals have been associated with effects ranging from neurotoxicity (2-methylphenol, benzidine) to liver effects, such as alterations in weight (butyl benzyl phthalate, hexachlorobenzene) and increased tumors (hexachlorobenzene) (EPA 1998b).

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Attachment B6: Portland Harbor Round 1 Fish TRV Selection

NOTE:

Detail on the methods for fish TRV selection will be submitted to EPA along with selected TRVs as a technical memorandum prior to the risk assessment.

1.0 INTRODUCTION

Toxicity reference values (TRVs) are toxicity thresholds that are compared to total exposure estimates for a given receptor to characterize ecological risk. The ecological risk assessment for Portland Harbor will include assessment of risk to fish species individuals or populations. Risk will be quantitatively characterized using the hazard quotient approach comparing either body burden or dietary doses to TRVs, depending upon the characteristics of metabolic breakdown for the particular chemical of concern (COC). This paper describes the process by which these TRVs will be identified.

In addition to this TRV approach, the risk of adverse effects to fish from direct water exposure will be assessed by comparing surface water chemical data to appropriate toxicity thresholds such as EPA's chronic ambient water quality criteria. Where appropriate thresholds are unavailable for a chemical, a literature-derived toxicity value will be developed as feasible.

The TRV derivation process involves simultaneous consideration of various factors and can't be completely summarized in a concise list of rules. Ultimately, best professional judgment plays a substantial role. However, defining the intent and method of searching for and evaluating TRVs before initiation of the TRV selection process assists in providing structure and maintaining consistency.

2.0 LITERATURE SEARCH PROCESS

Peer-reviewed publications will be targeted in a literature search including databases such as Ecotox and Environmental Residue Effects Database and review papers such as that by Jarvinen and Ankley (1999). The objective of the literature search is to find two categories of studies: studies where these endpoints were correlated with associated whole body tissue concentrations; or, for metabolizable chemicals, studies where growth, mortality or reproductive endpoints of chemical exposure through the diet were measured. Where studies that examine growth, mortality or reproduction endpoints are not available, studies that examine alternative endpoints (e.g., behavior, immune system effects) will be collected for review. All life-stages of fish will be included in the search. Chemicals targeted will be those analyzed in fish tissue and sediment collected during Round 1. Studies suitable for TRV derivation must have negative controls (control group showing no effects). The literature search will have the goal of being comprehensive, to find all relevant publications.

3.0 LITERATURE REVIEW PROCESS

All studies identified in the literature search will be obtained if feasible. Each paper will be reviewed systematically by completing a TRV Study Review Form (attached). This form documents information on the study design (e.g., chemical form, dose concentrations, test species), exposure (e.g., exposure period, frequency, vehicle), and effects (e.g., endpoint of effect, significance). There is also space to record comments regarding the study to highlight unusual characteristics that may be important in final selection of TRV studies.

The TRV Study Review forms will be signed by the original reviewer and then transferred with the paper to a QA reviewer. The QA reviewer will read through the study and associated form and make comments/edits as needed. There will be a single QA reviewer for all the fish TRV studies. The QA reviewer will be experienced in the review of exposure studies and TRV derivation. The QA reviewer will also sign the TRV Study Review form after his/her review is completed. Only studies that have been reviewed in this manner will be considered as source studies for TRV derivation. No TRVs will be based on secondary references or existing TRV compilations.

4.0 STUDY SCREENING

Once the papers have been reviewed and summarized, they will be prioritized in two steps. The first step will examine the following preferences:

- food is the preferred dose vehicle for derivation of dietary based TRVs (injection or water exposures may be considered if no dietary studies are available, but may not be necessarily accepted);
- for derivation of body burden based TRVs, exposure studies that include food dosing are preferable to those with only water exposure;
- For dietary TRVs: test chemical is in same form to which receptor would be exposed in the ISA. If multiple forms are believed to be present in significant quantity at the site, toxicity data for the most toxic chemical form will be selected;
- preferred exposure period is multigenerational > lifetime > chronic > subchronic > acute.
  Multigenerational>lifetime>chronic>subchronic.
  Multigenerational is defined as exposure through at least 2 generations; lifetime exposure is from birth to death; chronic exposure is through greater than 10 percent of the test species' average life expectancy or during a critical lifestage (i.e. reproduction, or development); subchronic exposure is from 10

percent or less of the test species' average life expectancy; acute exposure is < 1 percent of the test species' average life expectancy;

- test species that are most taxonomically similar to receptor are preferred;
- chemical exposure is to a single contaminant or to a mixture of contaminants that will be assessed as a mixture for the Site (i.e., Aroclors or PAHs);
- the effect level is proven to be statistically significant

When the number of studies remaining allows, the following preferences will be considered in step 2:

- Studies with larger sample sizes are preferred
- bounded NOAELs/NOECs and LOAELs/LOECs are preferable to unbounded
- multiple dose levels are preferred to single dose levels
- studies providing ingestion rates are preferred for dietary TRVs preferred to studies which require assumptions about ingestion rates.

The result of these screening steps will be a list of prioritized studies.

5.0 SELECTION PROCESS

As part of the final review process, studies that examine all three categories of endpoint (i.e. reproduction, growth and mortality) will be reviewed and the most sensitive endpoint will be selected for use as a TRV. Both low effect and no effects levels will be used in the ecological risk assessment. One of the objectives of the ecological risk assessment is to test the risk hypotheses. These hypotheses are based on assessment endpoints that are selected to protect fish populations of various feeding guilds from reproductive, growth and mortality effects, with the exception of listed species that are assessed at the individual level. With this objective, the low effect level will be applied as a population effect threshold and the no effect level will be applied as an individual effect threshold.

Regarding adverse effects, LWG considers adverse effects those that have been shown to directly impact reproduction, growth, or survival. LWG may consider physiological effects, such as endocrine disruption, if enough evidence exists showing a causal link to reproduction, growth, or survival.

For many receptor species, no toxicity data is available. In these scenarios, surrogate species will be selected based primarily on taxonomic relationship to the receptor species of interest.

There are situations where safety or uncertainty factors may be considered when determining NOAEL/NOEC and LOAEL/LOEC values. If low-effect values have no associated no-effect value, a safety factor will be applied to estimate the no-effect value. The other scenario where safety factors will be applied is where no chronic exposure studies are available. Safety factors will be used to estimate chronic exposure toxicity from subchronic or acute exposure studies.

Ultimately, the highest no effect value and lowest effect value for the most sensitive life-stage that occurs in the ISA, derived from qualified source studies, will be selected for use in the risk assessment. A summary of the studies reviewed and the rationale for final TRV selection will be presented in the PRE.

6.0 REFERENCES

Jarvinen AW, Ankley GT. 1999. Linkage of effects to tissue residues: Development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. SETAC Press, Pensacola, FL.

TRV STUDY REVIEW FORM

Chemical: _____

Bird Mammal Fish

LOAEL NOAEL LOEC NOEC

Reviewed by: _____ Date: _____

QA Review by: _____ Date: _____

Paper citation:_____

****

Study design

Test chemical: _____ Chemical form: _____

Test species: _____ Age: _____ Body weight: _____ Length _____

Life stage or breeding status: _____ Lipid content: _____

Number of males/females in test group: _____ No. of replicates: _____

Number of individuals in control group: _____

Test setting (circle): Lab Field

Exposure

Target dose concentrations (include control): _____

Measured concentrations (if available): _____

Background concentrations in control: _____

Exposure period (include static or flow-through system): _____

Exposure mode: _____

Exposure medium: _____

Dose frequency (circle): Daily Weekly Other: _____

Food consumption rate: _____

Effects

Effects tested:_____

Effects observed:_____

Statistically significant effects (circle)? Yes No

Lowest exposure concentration at which significant effects were observed for each endpoint:

_____

Highest exposure concentration at which no significant effects were observed for each endpoint:

_____

Comments:_____

_____

Attachment B7: A Review of Aquatic Food Web Models for Potential Application to the Portland Harbor Superfund Site

NOTE:

The selection of and proposed use of a food web model will be revised and submitted to EPA as a technical memorandum prior to the risk assessment.

1.0 INTRODUCTION

Food web models can be used for many different purposes, such as to track the fate of a chemical in the environment, to estimate bioaccumulation in particular organisms, or to establish preliminary remediation goals (PRGs) in a contaminated area. This tech memo is focused on the use of food web models to evaluate pathways of exposure to aquatic organisms and to establish PRGs for the Portland Harbor Superfund Site (Site). The baseline ecological risk assessment for Portland Harbor will culminate in the identification of areas could be associated with probable or possible adverse effects to aquatic life and wildlife. Similarly, the baseline human health risk assessment (HHRA) will identify areas could be associated with probable or possible adverse effects to human health. Results of the two risk assessments will be integrated to make risk management decisions that will be protective of human and ecological receptors. To successfully develop risk-based PRGs for sediment contamination, there must be a method to link risk to sediment concentrations. A food web model needs to be identified that incorporates exposure to sediments and allows for prediction of sediment concentrations from total exposure estimates. In addition, where unacceptable risk exists, the food web model may assist in the identification of major exposure pathways to receptors. To identify potential food web models, Windward searched for and reviewed published, peer-reviewed food web models for their applicability and relevance to Portland Harbor. This paper was intended to be the basis for discussion between the Lower Willamette Group (LWG) and the U.S. Environmental Protection Agency (EPA) and EPA's partners and is not intended to be the final decision of the LWG.

All food web models carry varying degrees of uncertainty associated with their output by virtue of the fact they are defined by human assumptions about reality. Some uncertainty can be described by validating model outputs with independent observations when possible. For the Portland Harbor Remedial Investigation (RI), the selected model will be calibrated with site-specific data and model predictions will be compared to observations collected during Round 1 data collection.

2.0 LITERATURE REVIEW

Publication databases (Biosis, ASFA, and Science Citation Index) and the existing Windward literature database were searched for papers discussing modeling of bioaccumulation of chemicals through aquatic food webs. Papers with original, generic food web models were targeted. Other papers that discussed new applications of these models were sometimes obtained but not reviewed and summarized as an original model. The World Wide Web was also used as a resource for locating validation studies, and determining existence of software packages and degree of use for particular models.

Four original food web models, three mass balance models and one fugacity model, were identified: the Gobas model (Gobas 1993), the Thomann model (Thomann et al. 1992), the Morrison et al. model (Morrison et al. 1997), and the fugacity model (Campfens and Mackay 1997). Following is a summary of each model with discussion of the appropriateness for application at the Site for the purpose of determining sediment PRGs based on ecological and human health risk. A summary of model structure and validation performance is presented in Table 1.

3.0 RESULTS OF MODEL REVIEW

3.1 The Gobas model

The Gobas (1993) food web model is a generic, 4-compartment, mechanistic chemical mass balance model. The four compartments of the food web are phytoplankton/macrophytes, zooplankton, benthic invertebrates, and fish. The phytoplankton/macrophyte model is a simple bioconcentration factor (BCF) approach dependent on the lipid content of the plant. Gobas (1993) assumes that the same approach can be used to model zooplankton because of their small size and large area/volume ratio. By using this approach to modeling phytoplankton and zooplankton bioaccumulation, Gobas (1993) assumes that uptake from diet is insignificant. The benthic invertebrate compartment is modeled as a biota sediment accumulation factor (BSAF) using equilibrium partitioning theory. The BSAF approach assumes that sediment is the only significant source of exposure to benthic invertebrates. The fish compartment incorporates chemical intake from gill respiration and diet and loss processes of metabolism, fecal elimination, growth dilution and gill elimination. These processes are modeled by first-order kinetics, which assumes bioaccumulation occurs by linear processes using rate constants. A weakness of using rate constants exists where they are used to represent terms that are actually variable. For example, first-order kinetics are used to model growth dilution in the Gobas model, in effect assuming that organisms grow at a constant rate throughout their lifetime (e.g., they grow 5 percent per year, forever). This is not an accurate representation of growth for fish. In addition to varying with time, some processes may vary between fish species and the first order kinetic terms of Gobas' model do not accommodate these differences. The actual rates of gill elimination and dietary uptake are also affected by factors other than just chemical concentration and hydrophobicity (K_{ow}), but Gobas (1993) assumes these factors are insignificant. The issues associated with the first order kinetics approach are not unique to Gobas's model and are shared by the other three models as well. The significance of some of these weaknesses, namely constant versus variable rates and interspecies differences, can be addressed by model analysis of additional scenarios (e.g., using parameters for different fish species, early life stage scenarios) and sensitivity analyses where rate constants can be varied to determine alternative outcomes.

This food web model was illustrated using Lake Ontario data for 63 organic chemicals (Gobas 1993). There was no statistically significant difference between measured and predicted concentrations in fish and benthic invertebrates. Fish taxa tested included salmonids, smelt, alewife, and sculpin. The model tended to overpredict benthic invertebrates and underpredict fish concentrations, but differences were usually less than a factor of two. The predicted concentrations in phytoplankton and zooplankton were lower than measured concentrations and within a factor of five. Gobas (1993) is not certain why this large difference exists, but the inaccuracy may be in the field data rather than the model because of sampling difficulties and small sample sizes.

Gobas (1993) models bioaccumulation by phytoplankton as equilibrium partitioning processes, controlled principally by the chemical's K_{OW} and secondarily by organic carbon concentrations. However, there is evidence that phytoplankton never reach chemical equilibrium with their environment during growth periods (Swackhamer and Skoglund 1993). This may be one explanation for the Gobas model poorly predicting phytoplankton concentrations.

The Gobas model has been widely applied and adapted to many projects and has been critically reviewed by government agencies such as the EPA. For example, the bioaccumulation algorithms of Gobas were used in the food web model for the Fox River RI/FS. Currently, the Army Corps of Engineers (ACOE) is funding development of a software program based on the Gobas model for use in dredging projects (Bridges 2002). This software will be available to download in January 2003. Frank Gobas also provides a Windows-based software program at the Simon Fraser University ToxLab website that uses an updated benthic invertebrate submodel based on Morrison et al. (1996).

3.2 The Thomann et al. model

The Thomann et al. (1992) food web model is the pelagic model of Thomann (1989) with the addition of a sediment component. Thomann et al. (1992) state that their model was designed to provide an improved method of linking sediment to an aquatic food web over the frequently applied simple partitioning method. This model is a generic, 5-compartment, mechanistic chemical mass balance model. The five compartments are phytoplankton/detritus, zooplankton, benthic invertebrates, forage fish and piscivorous fish. The phytoplankton and benthic invertebrate compartment models are more developed and comprehensive than those of the Gobas model. The phytoplankton/detritus compartment models uptake from water and loss by excretion and growth. The benthic invertebrate compartment incorporates uptake from interstitial and overlying water and dietary sources and the loss processes of fecal elimination, gill elimination, and growth dilution. The zooplankton, forage fish, and piscivorous fish compartments incorporate uptake from water and dietary sources, with diet parameters changing as appropriate for the organism. Uptake from water and sediment are both modeled as equilibrium partitioning processes, with the organic

components of the biota and the environmental compartments assumed to be in thermodynamic equilibrium. This may not be an appropriate assumption because these organic fractions are physically separated by aqueous compartments, most notably the blood of the organism, and, because of the relatively low solubility of hydrophobic organics in blood, this represents a rate-limiting barrier that may slow or prevent the attainment of thermodynamic equilibrium. For example, Barron et al. (1989) demonstrated that di-2-ethylhexylpthalate is metabolized in the gill arches as it diffuses from water to blood, thereby preventing entry into the fish tissues. Loss processes for these compartments include metabolic breakdown, fecal elimination, growth dilution, and gill elimination. One general algorithm was developed for all three of these compartments. Like the Gobas model, all uptake and loss rates are assumed to follow first-order kinetics (i.e., to be proportional to the concentration in a single model compartment).

Model parameters appear to be generally straightforward and obtainable through field-collected data or the literature. One possible exception is the zooplankton dietary fraction of food from the water column versus sediment (Burkhard 1998). This parameter was estimated by both Burkard (1998) and Thomann et al. (1992) by determining the best fit between predicted and actual bioaccumulation factors (BAFs) and BSAFs with varying proportions of uptake from water and sediment. However, the validity of the 'actual' BAFs and BSAFs has not been properly established through regression analysis.

In a paper by Burkhard (1998), BAFs determined from the Gobas and Thomann models were compared using Lake Ontario data. Measured and predicted BAFs were compared for PCBs, chlorinated pesticides, chlorinated benzenes, chlorinated toluenes, and hexachlorobutadiene. Burkhard made a small change to both models before performing this comparison. The bioavailability correction in the Gobas model was updated using a new submodel that distinguishes dissolved and particulate organic carbon phases. Burkhard also applies the same submodel to the Thomann model because any bioavailability correction is lacking from the model. Therefore, this paper is not comparing the exact same models published by Gobas (1993) and Thomann et al. (1992). With these changes acknowledged, predicted BAFs from the Gobas and Thomann models for phytoplankton were identical, and consistently lower than measured BAFs. For zooplankton, Diporeia, forage fish, and piscivorous fish, BAFs from both models were comparably predictive for chemicals with log K_{ow} from 3.0 to 8.0, with divergence occurring in BAFs for chemicals with log K_{ow}s > 6.0 (Gobas BAFs < Thomann BAFs). BAFs predicted by Thomann dropped significantly for chemicals with log K_{ow} greater than 8.0. This difference in model performance was attributed to a difference in how gill uptake efficiency is estimated. Current experimental data do not clarify which approach is more appropriate. It is difficult to evaluate the performance of either model in the log K_{ow} range greater than 8.0 because there were no measured BAF data for this range. Overall, both models were successful in predicting BAFs for chemicals with log K_{ow}s < 8.0. The Thomann model is more detailed for plankton and benthic invertebrate components, but

predicted chemical concentrations were similar for both models (Burkhard 1998). The Thomann model is available in Lotus 123 format from the author.

Burkhard (1998) also performed sensitivity analyses on the Gobas and Thomann models, modified as described previously. Burkhard changed each parameter input by 10 percent iteratively and compared the output. Burkhard determined that the Gobas and Thomann models have similar sensitivities, the most sensitive parameters being lipid contents, K_{ow}, and the sediment-water column concentration quotient. Also, feeding preferences for benthic invertebrates in the Thomann model were relatively sensitive.

3.3 The Morrison et al. model

The Morrison et al. (1997) food web model is a generic, 5-compartment, chemical mass balance model. The five compartments of the food web are: phytoplankton, zooplankton, filter-feeding benthic invertebrates, benthic detritivores, and fish. Bioconcentration in phytoplankton is modeled using organic carbon equilibrium partitioning. Bioaccumulation in filter-feeding benthic invertebrates is estimated differently than for benthic detritivores. Uptake processes for filter-feeders are assumed to be from respiration and suspended solids filtration. Benthic detritivores, zooplankton, and fish tissue concentrations are all estimated from the same algorithm assuming uptake is from respiration and food consumption. The loss mechanisms for all compartments of this model are comprehensive and the same as those in the Gobas model. Most model parameters are straightforward and obtainable through field-collected data or the literature. However, species-specific information on some physiological parameters, such as ventilation rates, ingestion rates, and assimilation efficiencies, may be difficult to obtain. For example, Morrison et al. (1997) provide no citation for values of PCB assimilation efficiencies in gills of zooplankton and benthic macroinvertebrates, and simply state that these are estimates without explaining their basis. These assimilation efficiencies could be critical parameters given that modeled zooplankton concentrations were sensitive to water concentrations and modeled fish concentrations were sensitive to changes in concentrations in their diet. It is possible that the estimates of these values Morrison et al. (1997) chose gave their model an optimum fit to the available data set. Morrison et al. (1999) note that the physiological rates are best-fit estimates and experimental data for these parameters are generally lacking. Similar parameters are used in all models except the Campfens and Mackay (1997) fugacity model.

Morrison et al. (1997) illustrated their model using PCB congener data from western Lake Erie. They changed some assumptions for this model application. Because metabolic transformation of PCBs is limited, this process was considered insignificant. Also, growth dilution was eliminated for zooplankton and benthic invertebrates to simplify the submodels. The predicted concentrations in benthic invertebrates (i.e., *Gammarus*, mayfly larvae, caddisfly larvae, zebra mussels, and crayfish), adult white sucker, silver bass, yellow perch, and walleye were in good

agreement with measured concentrations (ratio ranging from 0.89 to 1.11). Predicted concentrations in young-of-year fish, alewife, emerald shiner, troutperch, black crappie, white perch, freshwater drum, gizzard shad, smallmouth bass, and largemouth bass were lower than measured concentrations but within a factor of two. Measured concentrations in zooplankton were not available for direct comparison, but field-measured and predicted log BAFs in phytoplankton were compared. The predicted log BAFs (5.6–8.5) were slightly higher than field-measured log BAFs from the literature (4.8–8.0) and log BAFs that would be predicted in zooplankton from simple equilibrium partitioning theory (5.6–7.4). The authors concluded that their zooplankton bioaccumulation model was reasonable, although this conclusion may be the consequence of the absence of any field data to falsify it. Another application of this model was performed by Morrison et al. (1999) using Lake Ontario PCB and dioxin and furan congener data in invertebrates and fish. Eighty-six percent of predicted concentrations were within a factor of two of measured concentrations.

Both of the Morrison papers also conducted a sensitivity analysis of the model. For zooplankton, chemical concentration in the water was the most sensitive parameter. For Gammarus, chemical concentrations in the diet and assimilation efficiency were relatively sensitive parameters. Lipid content and concentration in the diet were the most sensitive parameters for filter-feeding invertebrates. All of the parameters tested for fish were equally sensitive. The sensitivity of most parameters varied with the contaminant K_{ow}.

The Morrison et al. model has been reviewed by the EPA and applied in part or in whole to EPA projects (EPA 1999).

3.4 The Fugacity model

The fugacity-based food web model, described by Campfens and Mackay (1997), is a thermodynamic model based on the concept of fugacity. Fugacity is the escaping tendency of a chemical from a particular phase (e.g., water, air) measured in units of pressure. Fugacity can be related to concentration by a fugacity capacity constant or Z factor. The convenience of a fugacity-based food web model is that one can estimate fugacity at any section of a food web using a single algorithm, and then determine concentration from that fugacity. This model, therefore, has an unlimited number of compartments. Campfens and Mackay build their fugacity model from the early bioaccumulation models of Thomann, which lacked a sediment component. As a result, their model assumes the same uptake and loss processes of the previously described Thomann model, with the exception that sediment exposure can only be modeled through the diet pathway. The principle of the fugacity model is to calculate partial fugacities for each phase that contributes to bioaccumulation of the chemical in an organism and then sum them to determine the total fugacity. Concentrations are calculated from corresponding fugacities. There are some unique features to parameterization of the fugacity model. For example, a number of physical parameters are required for the model, such as Henry's Law constant, vapor pressure,

and molecular mass. Also, concentrations are determined in units of mol/m^3, requiring more effort to obtain standard units of mg/kg. Despite the unusual nature of the parameters, they should be obtainable through field collected data or the literature.

The authors illustrate their model by application of PCB congener and total PCB data from Lake Ontario. Predicted concentrations in benthic invertebrates were consistently higher than measured concentrations, up to a factor of four. Fish and zooplankton concentrations were usually within a factor of three of measured concentrations. The performance of the fugacity model is the weakest of the four models reviewed. However, this model has been considered for application by the EPA (e.g., EPA 1999). Model software is available from Trent University.

Campfens and Mackay did not conduct a sensitivity analysis in their paper. Because this model was not a likely candidate for final selection, Windward did not search for sensitivity analyses.

4.0 APPLICABILITY TO PORTLAND HARBOR

The assumption of steady-state conditions is pre-defined for all the reviewed models. Portland Harbor is a dynamic, highly developed river system where contaminant inputs have been changing over time. The assumption of steady state is a weakness of all these models. However, rarely is there adequate data available to model dynamic conditions over time. Given that yearly COPC inputs to the Willamette River probably reached their maximum many years ago and sources of bioaccumulative contaminants have been present on the river for decades, it is not an unreasonable assumption that tissue bioaccumulation may be near steady state. For purposes of the RI, information regarding short-term changes in tissue bioaccumulation is not necessary. If desired, an estimate of long-term change may be extracted from statistical analyses or use of historical data in a separate application of a food web model.

The food web model that is applied to Portland Harbor will ideally be able to model bioaccumulation of any contaminant from sediment and surface water to biota, including benthic invertebrates and various trophic levels of fish. All of the models are capable of modeling any lipophilic contaminant and include compartments for phytoplankton, zooplankton, benthic invertebrates, and fish. However, there are differences in how the compartments are modeled and some models refine the compartments further. It should be noted that in a flowing river system, phytoplankton and zooplankton may represent an insignificant part of the food web, and that biological production may be more dependent on detritus inputs and potentially epiphytic production. Therefore, some modification of these models may

be necessary. The Gobas[3] model, by employing a BSAF approach, assumes that equilibrium partitioning adequately estimates bioaccumulation in benthic invertebrates. This approach assumes that sediment provides the only significant exposure source for benthic invertebrates. The fugacity model also assumes that equilibrium partitioning adequately estimates bioaccumulation by all biotic model components. The Thomann model and the Morrison et al. model estimate bioaccumulation from water and sediment sources to benthic invertebrates. Exposure to porewater, surface water, sediment, and prey are all included in the Thomann model. Surface water and diet exposure pathways to benthic detritivores are modeled in the fugacity and Morrison et al. models and sediment ingestion can be incorporated in the dietary exposure component. A unique feature of the Morrison et al. model is that filter-feeding benthic invertebrates are modeled differently than benthic detritivores. This could be a useful feature for the Portland Harbor Remedial Investigation (RI) if benthic filter feeders are determined to be an important prey item for upper trophic level organisms.

Flexibility is another feature of the ideal food web model. The exact food web structure should be adjustable to fit that of Portland Harbor, which has not yet been characterized. There are varying numbers of compartments modeled by these four models. Although the exact food web structure in Portland Harbor is currently unknown, a model that includes all the compartments that could be significant is advised. Compartments can be dropped from the food web model if they become irrelevant. The Morrison et al. model is recommended for its added feature of separate detritivorous and filter-feeding benthic invertebrate compartments. This feature may be useful if bioaccumulation from water is discovered to be significant in Portland Harbor because risks to benthic invertebrates from water and sediment contamination could be evaluated separately.

The parameters of the food web model need to be relatively easy to estimate using commonly collected site-specific data and/or general data from the literature. Although the fugacity model contains some unique parameters, they are no more difficult to estimate than parameters in the other models. However, the fugacity model does require a larger number of parameters to be estimated than any other model. All of the models use parameters that are not commonly collected in environmental monitoring. Parameters noted in the literature as difficult to collect include ‘zooplankton dietary fraction of food from water column versus sediment’ used in the Thomann model (Burkhard 1998), and the chemical physiological rates or rate constants used in all of the models except the fugacity model. Morrison et al. (1999) use best-fit estimates to obtain this latter parameter and Burkhard (1998) assumed zero metabolism in testing the Thomann and Gobas models because of the generally slow metabolism for PCBs and lack of data for other chemicals. Although

[3] Note that on his website, Gobas indicates that the benthic invertebrate compartment of his model has been updated with the Morrison et al. submodel.

all of the models use some parameters that may be difficult to estimate, no one model stands out as better or worse to parameterize.

Some consideration should be given to the ease with which the food web model will be explained and understood by interested parties. The Portland Harbor RI is a collaborative project involving potentially responsible parties, agencies, technical consultants, tribes, and public interest groups – a mixture of people with varying levels of technical training and experience. The fugacity model is not conceptually intuitive and may be difficult to explain to non-technical audiences. All of the mass balance models are easily described in a conceptual diagram.

Finally, the model needs to have been tested by comparison of predicted and measured concentrations. The performance of the fugacity model was poor even with the authors' own example application, with estimates frequently off by a factor of three or four. Performance on the example data sets was relatively good for the other three models. The Thomann and Gobas models were tested across chemicals of varying K_{ow}s and performed equally well, except for chemicals with very high log K_{ow} (>8.0). The Morrison et al. model was only illustrated using PCB data, but also performed well and matched measured tissue concentrations within a factor of two.

5.0 CONCLUSIONS AND RECOMMENDATION

Based on the above review, there are some clear advantages and disadvantages to some of the four models reviewed (Table 1). In validation, the fugacity model performed poorly relative to the mass balance models and also suffers from being conceptually difficult. Based on these factors, the fugacity model is not recommended for use in the Portland Harbor risk assessment. Of the three mechanistic mass balance models, all performed well; however the Morrison et al. model has been applied only to PCB and dioxin data. Its performance with regard to other chemicals is unknown. The Thomann and Gobas models have been used extensively. This review indicates that either of these models would be suitable for use in Portland Harbor. The Morrison et al. model has five compartments, with benthic invertebrates split into filter-feeding and detritivorous benthic invertebrates. This additional compartment could be advantageous if it is necessary to separate out risks to benthic invertebrates associated with water or with hardened surfaces from those associated with sediments. Based on these factors, the Morrison et al. model appears to be the strongest model for application to Portland Harbor. This model isn't as well-known as the Gobas and Thomann models, but it has similar structure and has been critically reviewed by EPA. Also, this model is comprehensive, flexible, and designed to be easily parameterized. Finally, this model has performed well for PCB and dioxin congeners and there is no basis to expect its performance would be different for other hydrophobic contaminants, except perhaps at high K_{ow}s where the Gobas and Thomann models also perform poorly.

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Attachment B8: Fish Stomach Content Screening

1.0 INTRODUCTION

Understanding the diet of receptor species is critical in developing realistic risk assessments. It is not possible to characterize the potential exposure of an organism without making assumptions about what it ingests. These assumptions are usually based on descriptions of the organism's diet from the literature. Since community composition (both taxonomic diversity and relative abundance) differs across ecosystems, it is unknown how representative the literature descriptions are. Analysis of the stomach contents of individuals collected at the assessment site is useful for fine-tuning assumptions about diet composition and improving exposure characterizations.

The only known previous stomach content analysis performed on the Willamette River was by Buchanan et al. (1981) and focused solely on northern pikeminnow (*Ptychocheilus oregonensis*). Over 1,000 fish were collected in the spring of 1976 and 1977 from stations well upstream of the Initial Study Area (ISA) (two just south of Salem and one on the outskirts of Eugene). They found that the northern pikeminnow diet was variable, but the major components were fish (mostly sculpin), crayfish, and insects.

During the summer and fall of 2002, the Lower Willamette Group (LWG) collected target fish species from the ISA for the Round 1 preliminary human health and ecological risk evaluation. The primary purpose was to collect fish for tissue residue analysis. The field effort, however, provided LWG with an opportunity to retain some specimens for a reconnaissance-level analysis of stomach content of the target fish species. This study was not conducted to comprehensively examine and record the diets of the target fish species in the Lower Willamette River.

2.0 OBJECTIVES

The objective of this study was to develop a qualitative understanding of the potential diet of target fish species captured in the ISA.

3.0 METHODS

This section describes the field methods used to capture the target fish species and the laboratory methods used to remove and identify the stomach contents from each fish.

The fish used in this study were collected for the Round 1 preliminary risk evaluation, but were diverted for stomach content analysis once the tissue mass quotas for laboratory analyses were met for each species.

3.1 Field methods

The fish used in this study were caught between October 2 and November 8, 2002 using one of the six collection methods indicated in Table 1; see the Round 1 Field Sampling Plan for further details. Once caught, fish were placed in labeled Ziploc® bags and stored on ice until they were delivered to the fish-processing laboratory later the same day.

3.2 Laboratory methods

Upon arrival in the laboratory, fish were immediately transferred to a refrigerator until processing. All of the fish were processed within two days of capture, and most were processed within one day.

3.2.1 Stomach content removal

The fish were removed from the refrigerator and measured (total length) and weighed. The fish were dissected using a dissecting knife or fillet knife, depending on the size and species of fish. The stomach was located and removed from the fish. The stomach was then opened and the contents removed to a pre-labeled glass jar with 50% denatured ethanol as preservative. The jars were stored until they were returned to Seattle for identification.

3.2.2 Content identification

The contents of each jar were emptied onto a glass Petri dish under a dissecting scope and all contents were identified to the highest taxonomic level.

4.0 RESULTS

A total of 35 fish from seven species were collected for stomach content analysis (Table 1). Receptor species representing three of the four feeding guilds defined in the Ecological Risk Approach appendix to the Round 1 Work Plan (Windward 2003) were represented in the species collected. Peamouth (*Mylocheilus caurinus*) and sculpin (*Cottus* sp.) represent invertivorous fish, smallmouth bass (*Micropterus dolomieui*) and northern pikeminnow represent piscivorous fish, and largescale sucker (*Catostomus macrocheilus*) represents herbivorous/omnivorous fish. The only representative species absent from this analysis are juvenile chinook salmon and Pacific lamprey. Also among the fish collected were black crappie (*Pomoxis nigromaculatus*), which are piscivorous and are a target species in the human health risk assessment, and brown bullhead (*Ameiurus nebulosus*). Brown bullhead are in the same feeding guild as largescale sucker but are not a target species for either of the risk assessments. However, they are ecologically similar to yellow bullhead (*Ameiurus natalis*), a target species in the human health risk assessment.

Table 1. Stomach contents of target fish species caught in the ISA

Feeding Guild	Fish Species	Date Caught	Total Length (MM)	Weight (G)	Location	Collection Method	Stomach Content
Herbivore/ Omnivore	Largescale sucker	10/25/02	425	776.7	RM 8, Swan Isl. Lagoon	boat electrofishing	Bivalve (*Corbicula sp.*), chironomids, oligochaetes, bryozoans, gastropods, filamentous algae, sediment
		10/25/02	455	935.8	RM 8, Swan Isl. Lagoon	boat electrofishing	Bivalve (*Corbicula sp.*), chironomids, oligochaetes, bryozoans, gastropods, filamentous algae, sediment
		10/25/02	446	875.6	RM 8, Swan Isl. Lagoon	boat electrofishing	Bivalve (*Corbicula sp.*), chironomids, oligochaetes, bryozoans, gastropods, filamentous algae, sediment
		10/25/02	410	783.9	RM 6	trotline	Filamentous algae, detritus, sediment
	Brown bullhead	na	na	na	na	na	Chironomids, filamentous algae
		10/29/02	292	316.9	RM 4	trotline	Roundworm (parasite), unidentified invertebrate, filamentous algae, detritus, sediment
Invertivore	Sculpin (4)[a]	10/2/02	118, 112, 104, 107	19, 17, 13, 14	RM 8, Swan Isl. Lagoon	backpack electrofishing	Amphipods, gastropods (limpet, *Fisherola* sp.; snail, *Physa* sp.)
	Sculpin	10/15/02	166	62.4	RM 9	trotline	Amphipods, bryozoans
		10/15/02	109	13.7	RM 9	trotline	Roundworm (parasite)
		10/24/02	107	14.6	RM 3	backpack electrofishing	Dipteran (Family Sciomyzidae), gastropod (snail, *Physa* sp.)
		11/7/02	135	22.8	RM 7	crayfish trap	Bryozoan and statoblast (*Cristatalla mucedo*), unidentifiable
	Peamouth	10/29/02	190	62.6	RM 3	beach seine	Filamentous algae, terrestrial insect (wasp), sediment
		10/29/02	200	67.1	RM 4	trotline	Fish (unidentifiable), terrestrial insect (wasp)

Feeding Guild	Fish Species	Date Caught	Total Length (MM)	Weight (G)	Location	Collection Method	Stomach Content
		11/5/02	271	172.5	RM 8	trotline	Bryozoan and statoblast (*C. mucedo*)
		11/5/02	284	196.3	RM 3	na	Filamentous algae, sediment
		11/5/02	280	165.5	RM 3	na	Bryozoan and statoblast (*C. mucedo*), filamentous algae, terrestrial insect (wasp), sediment
Piscivore	Northern pikeminnow	10/24/02	224	97.5	RM 7	na	Roundworm (parasite), unidentifiable structures
		11/8/02	498	1087.1	RM 4	trotline	Fish (unidentifiable), amphipod
		NA	422	714.2	NA	na	Fish (3-spine stickleback), detritus
		11/6/02	398	582.4	RM 7	boat electrofishing	Fish (unidentifiable), crayfish
		11/7/02	460	421	RM 7	trotline	Fish (unidentifiable)
		11/7/02	255	115.1	RM 7	trotline	Crayfish
	Smallmouth bass	10/9/02	230	179.6	RM 5	boat electrofishing	Crayfish
		10/11/02	270	250	RM 6	boat electrofishing	Crayfish
		10/11/02	260	232.4	RM 6	boat electrofishing	Crayfish
		10/17/02	NA	NA	RM 8, Swan Isl. Lagoon	boat electrofishing	Water mite (Order Hydrachnida) bryozoan and statoblast (*C. mucedo*)
	Black crappie	10/15/02	249	224.8	RM 6-9	boat electrofishing	Fish (unidentifiable), isopod
		10/17/02	129	169.5	RM 6-9	boat electrofishing	Fish (shad), bryozoan and statoblast (*C. mucedo*)
		11/5/02	196	119	RM 6-9	hook and line	Amphipods

Feeding Guild	Fish Species	Date Caught	Total Length (MM)	Weight (G)	Location	Collection Method	Stomach Content
		11/5/02	196	127.2	RM 6-9	hook and line	Isopods
		11/6/02	227	156.1	RM 4	trotline	Crayfish
		11/6/02	224	215	RM 6-9	na	Unidentifiable

na – not applicable

[a] The stomach contents from four sculpin were preserved in the same jar

Of the 35 fish caught, 13 were invertivores (37%), 16 were piscivores (46%), and 6 were herbivore/omnivores (17%); 24 were collected from the upper half of the ISA (RM 6-9), and 10 of those were caught in Swan Island Lagoon (Table 1).

Overall, northern pikeminnow was the most reliably piscivorous species: four of six examined had fish in their stomachs. Two (of six) black crappie and none of the smallmouth bass examined had fish in their stomachs. Crayfish were the dominant prey of the four smallmouth bass examined, and a mix of aquatic invertebrates made up the rest of the black crappie stomach contents.

The sculpin examined were true invertivores with the exception of one infected with parasites which had only parasitic roundworms in its stomach. Stomach contents of all other sculpin were a mix of aquatic invertebrates including amphipods, gastropods, and bryozoans. Aquatic invertebrates did not, however, dominate the stomach contents of the five peamouth examined. Three of the five peamouth had ingested filamentous algae and terrestrial wasps.

Filamentous algae were found in the stomachs of all six herbivores examined. Largescale suckers were found to have ingested a variety of aquatic invertebrates usually associated with soft sediments (e.g., bivalves, chironomids, gastropods, oligochaetes). It is not surprising, therefore, that sediments were also found in the stomachs of all four sucker. The two brown bullhead examined were both found to have ingested filamentous algae and invertebrates. Sediments and detritus were also found in one bullhead.

Bryozoans were the most common item in the 35 fish stomachs examined (Table 2). They are sessile, colonial filter feeders that are superficially similar to marine corals. In the fall, bryozoans form dormant buds called statoblasts where they remain through the winter (Wood 2001). Mature bryozoans and/or their statoblasts were found in individuals from each of the three feeding guilds represented and five of the seven species examined. This is surprising given that Wood (2001) states that extensive fish predation on bryozoans has not been verified in the literature. These data alone are not adequate to determine whether fish are targeting bryozoans as a food resource or if their ingestion is more incidental. One study has suggested that fish may graze on bryozoans because they are sometimes inhabited by insect larvae (e.g. chironomids; cited in Wood [2001]).

5.0 CONCLUSIONS

It is difficult to draw many conclusions from such a small dataset. However, three findings are worth noting.

- Bryozoans were a common item ingested by fish from all feeding guilds.

- Sediments were found in the stomachs of only those individuals that also ingested filamentous algae. Only one individual that ingested algae did not have sediment in its stomach.
- The smallmouth bass appear to be ingesting crayfish.

Table 2. Distribution of stomach contents by species and number of individuals

Stomach Content	# of species (out of 7)	# of individuals (out of 35)
Filamentous algae	3	9
Bryozoan	5	9
Bivalve (*Corbicula*)	1	3
Gastropods	2	At least 5
Oligochaetes	1	3
Chironomids	2	4
Crayfish	3	6
Amphipods	3	At least 4
Isopods	1	2
Fish	3	7
Detritus	3	3
Sediment	3	8
Terrestrial insects	1	3
Water mites	1	1

6.0 REFERENCES

Buchanan DV, Hooton RM, Moring JR. 1981. Northern squawfish (*Ptychocheilus oregonensis*) predation on juvenile salmonids in sections of the Willamette River basin, Oregon. Can J Fish Aquat Sci 38:360-364.

Windward. 2003. Portland Harbor round 1 work plan, appendix C: Ecological risk approach. Windward Environmental LLC, Seattle, WA.

Wood T. 2001. Bryozoans. In: Thorp J, Covich A, eds, Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego, CA. pp 505-525.

Attachment B9: Portland Harbor Round 1 Bird and Mammal TRV Selection

NOTE:

Details on the methods for wildlife TRV selection will be submitted to EPA along with selected TRVs as a technical memorandum prior to the risk assessment.

1.0 INTRODUCTION

Toxicity reference values (TRVs) are toxicity thresholds that are compared to total exposure estimates for a given receptor to characterize ecological risk. The ecological risk assessment for Portland Harbor will include assessment of risk to birds and mammals. Risk will be quantitatively characterized using the hazard quotient approach, comparing estimated total exposure to TRVs in terms of body-weight normalized daily doses. This paper describes the process by which these TRVs will be identified.

The TRV derivation process involves simultaneous consideration of various factors and can't be completely summarized in a concise list of rules. Ultimately, professional judgment plays a substantial role. However, defining the intent and method of searching for and evaluating TRVs before initiation of the TRV selection process assists in providing structure and maintaining consistency.

2.0 LITERATURE SEARCH PROCESS

Peer-reviewed publications will be targeted in a literature search including databases such as Ecotox and Toxnet and review articles such as the USFWS Biological Reports and ATSDR mammalian toxicity documents. The objective of the literature search is to find studies where growth, mortality, or reproductive endpoints of chemical exposure through the diet were measured. These general types of endpoints are commonly used in ecological risk assessment and are specifically identified as objectives for the RI in the AOC (EPA 2002). Where studies that examine growth, mortality or reproduction endpoints are not available, studies that examine alternative endpoints (e.g., behavior, immune system effects) will be collected for review. All life-stages of birds and mammals will be included in the search. Chemicals targeted will be those analyzed in fish tissue and sediment collected during Round 1. Studies suitable for TRV derivation must have negative controls. The literature search will have the goal of being comprehensive, to find all relevant publications.

3.0 LITERATURE REVIEW PROCESS

All studies identified in the literature search will be obtained if feasible. Each paper will be reviewed systematically by completing a TRV Study Review Form (attached). This form documents information on the study design (e.g., chemical form, dose concentrations, test species), exposure (e.g., exposure period, frequency, vehicle), and effects (e.g., endpoint of effect, significance). There is also space to include comments regarding the study to highlight unusual characteristics that may be important in final selection of TRV studies.

The TRV Study Review forms will be signed by the original reviewer and then transferred with the paper to a QA reviewer. The QA reviewer will read through the study and associated form and make comments/edits as needed. There will be a maximum of 2 QA reviewers for the bird and mammal TRV studies. QA reviewers will be experienced in the review of exposure studies and TRV derivation. The QA reviewer will also sign the TRV Study Review form after his/her review is completed. Only studies that have been reviewed in this manner will be considered as source studies for TRV derivation. No TRVs will be based on secondary references or existing TRV compilations.

4.0 STUDY SCREENING

Once the papers have been reviewed and summarized, they will be prioritized in two steps. The first step will examine the following preferences:

- Food is the preferred dose vehicle (IP injection and oral gavage may be considered if no dietary studies are available, but may not be necessarily accepted);
- Wild test species are generally preferred over domestic test species. For example, chickens can be extremely sensitive to chemicals and are bred to maximize reproductive production. Therefore, this species would be least appropriate to represent a wild species.
- For dietary TRVs, the test chemical is in same form to which receptor would be exposed in the ISA. If multiple forms are believed to be present in significant quantity at the site, toxicity data for the most toxic chemical form will be selected.
- Preferred exposure period is multigenerational>lifetime>chronic> subchronic. Multigenerational is defined as exposure through at least 2 generations; lifetime exposure is from birth to death; chronic exposure is through greater than 10 percent of the test species' average life expectancy (greater than 10 weeks for birds and greater than one year for mammals) or during a critical lifestage (i.e. reproduction, gestation, and development); subchronic exposure is 10 percent or less of the test species' average life expectancy.
- Test species that are most taxonomically similar to receptor and have similar physiology are preferred.
- Chemical exposure is to a single contaminant or to a mixture of contaminants for which clear effects of the chemical of interest can be identified and distinguished quantitatively from those of other chemicals;

- The effect level is proven to be statistically significant

When the number of studies remaining allows, the following preferences will be considered in step 2:

- Studies with larger sample sizes are preferred
- Bounded NOAELs and LOAELs, where the study observed an effect at one dose/concentration and no effect at another (in addition to control) for the endpoint of interest, are preferable to unbounded
- Multiple dose levels are preferred to single dose levels
- Studies where the dosed food was a prey item are preferred to those where lab chow is offered.
- Studies providing ingestion rates are preferred to studies which require assumptions about ingestion rates.

The result of these screening steps will be a list of prioritized studies.

5.0 SELECTION PROCESS

As part of the final review process, studies that examine all three categories of endpoint (i.e. reproduction, growth and mortality) will be reviewed and the most sensitive endpoint will be selected for use as a TRV. Both LOAELs and NOAELs will be used in the ecological risk assessment. One of the objectives of the ecological risk assessment is to test the risk hypotheses. These hypotheses are based on assessment endpoints that are selected to protect wildlife populations of various feeding guilds from reproductive, growth and mortality effects, with the exception of listed species which are assessed at the individual level. With this objective, the LOAEL will be applied as a population effect threshold and the NOAEL will be applied as an individual effect threshold.

Regarding adverse effects, LWG considers adverse effect those that have been shown to directly impact reproduction, growth, or survival. LWG may consider physiological effects, such as endocrine disruption, if evidence is strong enough to show a causal link to reproduction, growth, or survival at the appropriate level of protection (i.e. population or individual).

For many receptor species, no toxicity data is available. In these scenarios, surrogate species will be selected based primarily on taxonomic relationship to the receptor species of interest. Where it is appropriate, relative body size will also be taken into account as a basis for surrogate selection. Body weight can be used as a measure of metabolic rate, which is one measure of physiological similarity. EPA (1993) discusses the inverse relationship between body size and metabolism that generally occurs in birds and mammals. For example, in selection of a surrogate, if the test

species available from toxicity studies are the rat and raccoon and the receptor is a shrew, the rat would be selected as the most appropriate surrogate, because it is closer to the target receptor in metabolic rate. The rat is in the order Rodentia and the raccoon is in the order Carnivora—neither is an insectivore. However, the rat is a much smaller mammal than a raccoon with a correspondingly faster metabolic rate than the raccoon, and more closely resembles the metabolic rate of the shrew, also a much smaller mammal than a raccoon.

There are situations where safety or uncertainty factors may be considered when determining NOAEL and LOAEL values. If LOAEL values have no associated NOAEL value, a safety factor will be applied to estimate the NOAEL. The other scenario where safety factors will be applied is where no chronic exposure studies are available. Safety factors will be used to estimate chronic exposure toxicity from subchronic exposure studies.

The calculations of NOAEL and LOAEL values will be performed using all the available relevant data from the study (i.e., ingestion rates, body weight). Where information is lacking from the study, values will be estimated using other literature sources for the test species. These will be selected by matching the characteristics of the test species (i.e., size, age, type of diet) as closely as possible. Ultimately, the highest NOAELs and lowest LOAELs derived from qualified source studies will be selected for use in the risk assessment. In cases where the highest NOAEL is higher than the lowest LOAEL, the studies will be reviewed in the context of the other available toxicity studies, preferably the most valid studies identified in the screening process. The other existing dose-response data will be considered as a “reality check” to determine if an alternative, more representative and qualified study should be selected for the NOAEL or LOAEL. A summary of the studies reviewed and the rationale for study rejection and final TRV selection will be presented in the Round 1 Preliminary Risk Evaluation.

6.0 REFERENCES

EPA. 1993. Wildlife exposure factors handbook. Volume I. EPA/600/R-93/187a. Office of Research and Development, US Environmental Protection Agency, Washington, DC.

EPA. 2001. Administrative order on consent for remedial investigation/feasibility study for Portland Harbor Superfund Site. US Environmental Protection Agency Region 10, Portland, OR.

TRV STUDY REVIEW FORM

Chemical: _____

Bird Mammal Fish

LOAEL NOAEL LOEC NOEC

Reviewed by: _____ Date: _____

QA Review by: _____ Date: _____

Paper citation:_____

****

Study design

Test chemical: _____ Chemical form: _____

Test species: _____ Age: _____ Body weight: _____ Length _____

Life stage or breeding status: _____

Number of males/females in test group: _____ No. of replicates: _____

Number of individuals in control group: _____

Test setting (circle): Lab Field

Exposure

Target dose concentrations (include control): _____

Measured concentrations (if available): _____

Background concentrations in control: _____

Exposure period (include static or flow-through system): _____

Exposure mode: _____

Exposure medium: _____

Dose frequency (circle): Daily Weekly Other: _____

Food consumption rate: _____

Effects

Effects tested:_____

Effects observed:_____

Statistically significant effects (circle)? Yes No

Lowest exposure concentration at which significant effects were observed for each endpoint:

_____

Highest exposure concentration at which no significant effects were observed for each endpoint:

_____

Comments:_____

_____